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SEPTEMBER, 1921

MINING ORIENTAL RUBIES IN THE FAMOUS DISTRICTS OF UPPER BURMA—NATIVES EXCAVATE LARGE OPEN PITS AND THE RUBY EARTH IS THEN CRUSHED AND WASHED.

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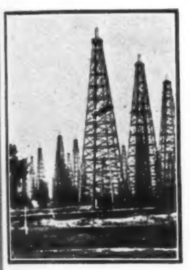
Oil Sands Must be Made to Yield More Abundantly

Compressed Air Promises to be of Great Service in this Vital Field of Industry by Increasing Production of Petroleum from Pumping Wells

By ROBERT G. SKERRETT



THE IMPORTANCE of petroleum and its derivatives has been augmented tremendously in the course of the last ten years; and the industrial, commercial, and defensive capacities of a nation will hereafter depend largely upon the quantities of so-called crude oil which it can command both normally and in emergencies. In short, it is daily becoming more evident that not only must every underground pool of petroleum be drained to the utmost practicable limit but it is equally imperative that wastages during mining and storage of the oil be prevented or minimized as far as possible.

Less than 25 years ago the use of liquid fuel on shipboard was generally viewed askance. It is a matter of record what difficulties had to be overcome to guard against explosive gases in the tanks and, likewise, what engineering cunning was called into play to make it feasible to get really satisfactory combustion of the fuel in the boiler furnaces. But who does not know to-day of the great propulsive economies which have been achieved in shipping circles by the adoption of liquid fuel? The coal-burning battle craft is obsolescent, and the coal-burning vessel of trade is also a back number when compared with the efficiency and the operating cost of her sister ship raising steam by means of oil.

But the changes wrought in maritime circles by the employment of petroleum are scarcely more than a hint of what is sure to come in the near future by a still better use of this source of energy. The heavy-oil engine as a power producer is the superior of the steam engine in a number of particulars; and scores of technical concerns are now engaged in the building and the designing of bigger and bigger units of the Diesel type.

INSIDE OF two decades petroleum and its derivatives have been instrumental in bringing about a veritable revolution in the realm of motive power.

Liquid fuel for the steam plant, gasoline for the internal combustion motor, and heavy oil for the Diesel engine have become indispensable because of the greater efficiencies and economies made possible through the adoption of the so-called newer combustible. And from the same primary crude oil are obtained numerous lubricants suited to all sorts of operative circumstances.

It is no exaggeration to say that the nation that cannot command an abundance of petroleum and its by-products will be gravely hampered in all of its industrial and commercial efforts.

Therefore, nothing should be left undone to drain every possible drop from the pools that are tapped. In this endeavor compressed air is likely to prove of great value.

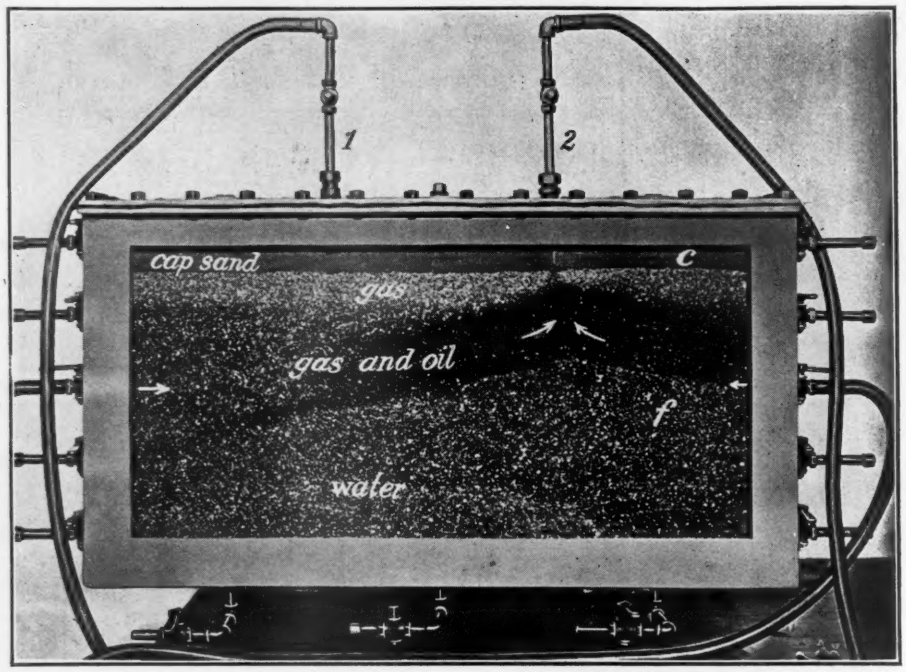
One large steel company has had in service for a while two ocean-going ore carriers, both of them structurally identical save that one is driven by a thoroughly up-to-date steam plant burning oil fuel while the other is propelled by oil engines. The latter, for a given performance, consumes about 63 per cent less fuel oil than its companion craft.

Manifestly, it is vital to any country seeking an outlet for its goods in the competitive markets of the world that it be able to deliver its commodities in bottoms which shall be capable of traveling fast and far and to do this as cheaply as those of its rivals. And then back of this oversea system of distribution, the mill, the factory, and the farm must be in a position to count confidently upon a plenty of low-priced mechanical power.

The agriculturist has learned of late what the tractor and oil-driven mechanisms of various sorts can do to lighten his load, make his acres more fruitful and, withal, render rural life less irksome. The oil-fired steam plant and the internal combustion engine have profoundly altered the operative story of the factory and thousands of shops devoted to all kinds of work. The oil-burning locomotive is a necessity in some parts of the United States and also in other sections of the globe; and great electric generating stations are one after another turning to oil in place of coal for fuel.

But, probably the most spectacular development of the internal combustion engine, measured in a quantitative sense, is in the field of the automotive vehicle. Last year we had registered in service no fewer than 9,211,295 motor cars and trucks, not to mention 238,146 motor cycles. All of these required gasoline for their energizing. The number of these domestic carriers increased 22 per cent. between 1919 and 1920; and no one can say with certainty at what rate the use of these conveyances will be amplified in the course of the next five years. The flotillas of motor boats and kindred small craft equipped with gasoline auxiliaries are becoming larger from season to season. Finally, the navigation of the air will, ere long, demand immense quantities of liquid fuel for the propulsion of dirigibles and flying machines.

But petroleum when employed as a primary source of energy fulfills but one of its diversified applications. Don't let us forget that it is upon crude oil we depend principally for numerous lubricants suited to make the



Courtesy, U. S. Bureau of Mines.

The Mills' apparatus in action. f. A body of pay sand surmounted by a compact cap sand c. The arrows at the right and left sides indicate the points at which compressed air, representing gas, was admitted. The action of the expanding air causes the formation of an oil cone immediately below the line of escape, outlet 2. (See pp. 10209).

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A producer in the Texas oil fields. Note how close the wells are spaced in the feverish effort to drain quickly nature's store below ground.

wheels of our busy existence turn with a minimum of friction. From the original petroleum our refineries extract oils fit for lubricational purposes under all loads and temperatures. We should, indeed, be heavily handicapped, in fact gravely circumstanced, if these oils were not at hand. In a lesser, but very significant way, we draw from crude oil a long list of pharmaceutical preparations, coloring agents, and essential chemicals.

Less than twelve months ago, Doctor George Otis Smith, Director of the United States Geological Survey, made this startling statement: "The monthly consumption of crude petroleum in the United States and the exports of refinery products, taken together, have but once in the last two years been less than our domestic production, and for about half of the time the consumption has exceeded both the domestic production and the imports. This living beyond our means makes the question of our present oil supply not only a national but an international problem. And the outlook is not improving; indeed, never was the gap between consumption and production wider than it is now. . . . In September of this year (1920), as in August, the daily output of the United States oil wells was slightly over 1¼ million barrels, but the daily consumption rose to 1⅝ million barrels.

"This daily deficit of three-eighths of a million barrels was met by imports from Mexico. To this extent, then, we are already dependent upon a foreign supply of oil, and even our accumulated stocks of domestic oil at tank farms, although a reminder of the days of plenty, afford too small a promise of relief, for the oil really available in storage is less than that which will be imported from Mexico this year. Although reputed to be the nation richest in oil, the United States cannot stand alone."

The situation is even more disturbing than the foregoing statement might imply at first blush, because extraordinarily bountiful as has been the yield of the proved Mexican fields, still we are told by recognized experts that these areas will probably cease to bear inside of two or three years. In 1920, the United States consumed 531,186,000 barrels of petroleum—87,724,000 barrels more than the country obtained from its own wells. Even excluding our exports of crude and refined products, totalling 70,000,000 barrels, domestic needs exceeded native resources by over 13,000,000 barrels.

Heretofore, America has predominated in the petroleum industry; and in the course of three-score years has contributed right along fully 44 per cent. of the world's output of oil. But to-day, it is imperative that we mine our petroleum much more efficiently than in the past, because the scientists tell us that we have exhausted by quite 40 per cent. our subterranean stores of this precious fluid. While we still have underground more than half of nature's estimated bounty, unhappily our rate of consumption runs annually into increasing billions of barrels, and we are authoritatively informed that, unless the unexpected happens, our wells will cease to yield within twenty or 30 years!

While this outlook is disquieting, there is warrant for the belief that engineering skill may devise means to postpone the day of failure by making it possible to draw off a greater proportion of the oil than has been feasible up to the present time. With the apparatus commonly in use in the oil fields it is estimated by some technicists that not less than 50 per cent. remains unrecovered in the pool, but there are others who are equally certain that only ten to twenty per cent. of the oil in a given area is brought to the surface by the prevailing methods.

There are many factors that have to do with the natural or normal flow of an oil well, but it is not the purpose of this article to dwell upon them and their interrelations. The closed or "rock" pressure factor is the primary impulse in most instances that stimulates the flow of the oil surfaceward when once the dome or reservoir has been tapped by the drill. To put it popularly, the situation of the oil is somewhat akin to that of the fluid in a Hero's fountain—familiar to every student of elementary physics, but with this difference; the oil is not only superposed by a volume of compressed gas but the oil, itself, is charged with gas much like the contents of a bottle of soda water.

The vent opened by the driller's tool offers an avenue of escape for the confined gas immediately under the dome and for the gas held in solution by the petroleum; and if the lower end of the well casing be suitably located, the expulsive effort of the expanding gas will drive the oil up the pipe or force the oil through the sand or rock to the intake of the casing whence pumps at the surface can lift it.

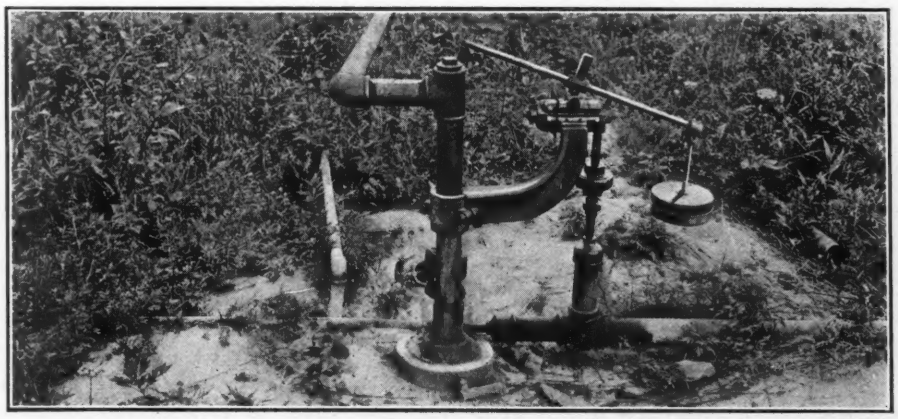
By reason of the disposition and the load of the overlying rock, the gas pressure in a pool or dome may range from a few hundred pounds up to 1,000 pounds and more. These conditions were strikingly illustrated when the world's greatest oil gusher, Cerro Azul No. 4, near Tampico, was brought in in February of 1916. At that time the measured flow amounted to 260,000 barrels of oil daily; and the geyser of petroleum was shot skyward to a height of from 500 to 600 feet. Broadly stated, as a general proposition, the recovery of oil is largely dependent upon the amount and the pressure of the gas associated with it. And as the output of petroleum decreases from a well so, too, does the quantity of the gas emitted fall away.

In view of this fact, the best practice is to check the rapid and impetuous escape of the impulse gas during the earlier period of a well's activity for the purpose of prolonging production through nature's own expelling medium. Even so, there comes a time when the gas remaining underground, if any be left, cannot exert sufficient pressure to push the oil before it to the shot hole at the bottom of the casing, let alone to impel it surfaceward. This state of the well does not mean that the "pay streak" may not still hold a considerable measure of oil. The problem is how to induce this oil to move through the sand or rock to the shot hole where it can be dealt with by the suction of the pumps. Va-

Using Compressed Air in Various Ways for the Extraction of Oil—It Has Proved Adaptable for Many Different Purposes

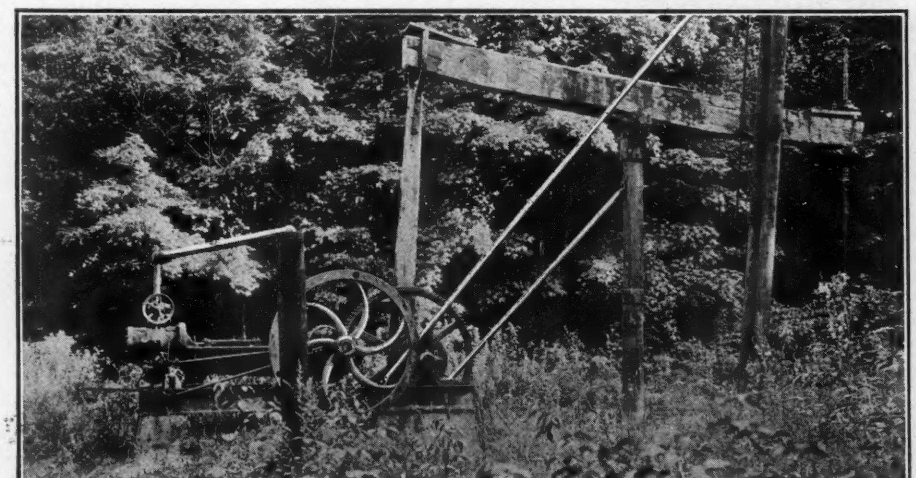
Courtesy, U. S. Bureau of Mines.

A well equipped for taking compressed air. Showing the piping connections and method of capping the well for the introduction of air pressure.



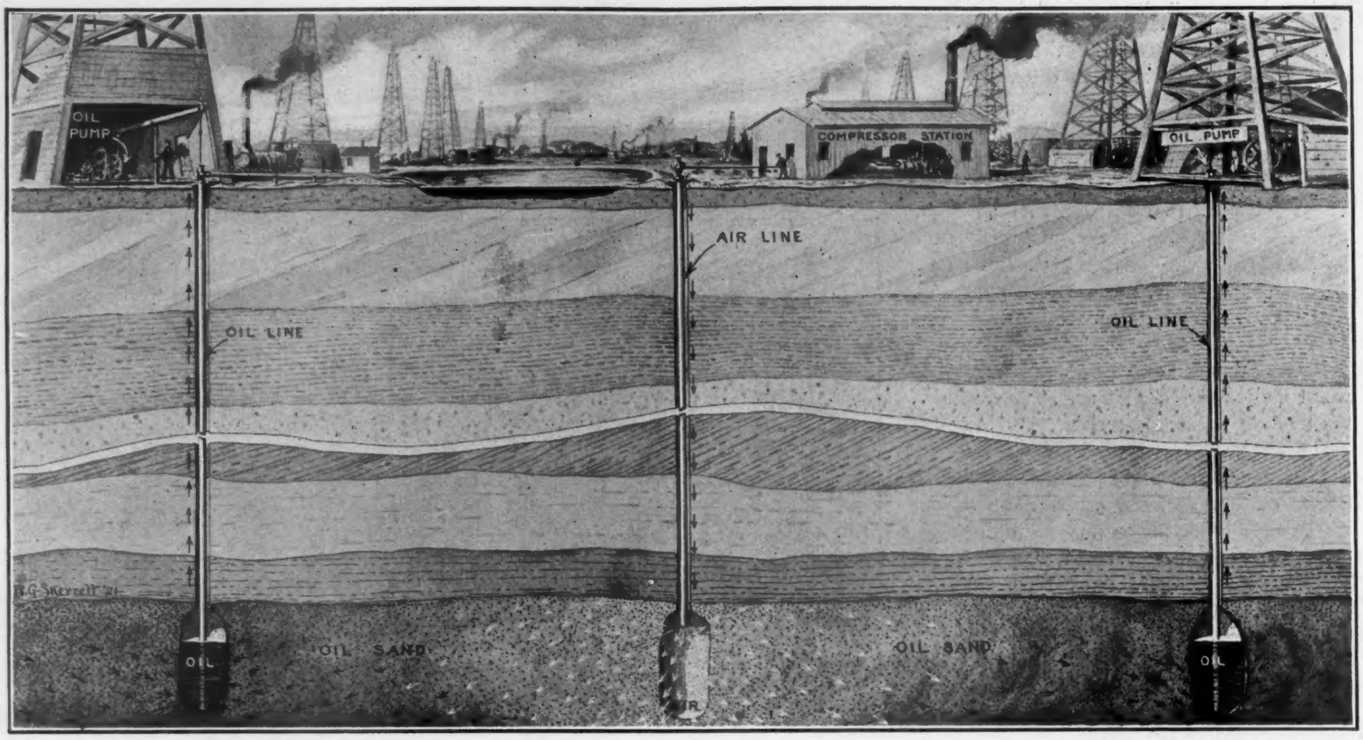
Courtesy, U. S. Bureau of Mines.

An oil pump run by compressed air. This equipment was installed on a property in Ohio. These pumps can be installed at a considerable distance from the central power plant without occasioning any significant losses in power transmission when air is used.



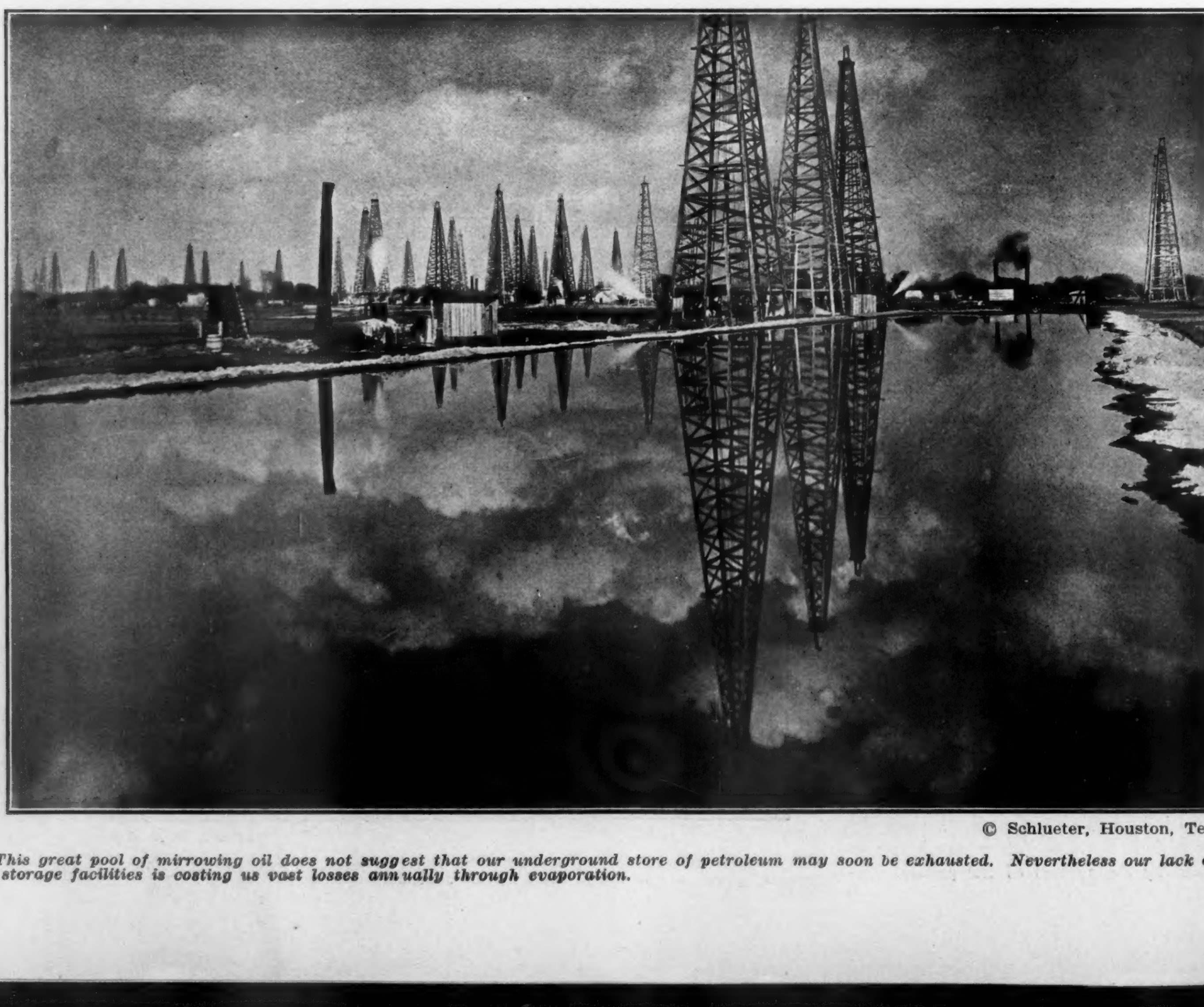
Courtesy, U. S. Bureau of Mines.

Pumping a well "on the beam" with Barcroft pumping gear run by compressed air. Various types of pumps are in use in the oil fields depending upon circumstances.



Courtesy, Scientific American.

Diagrammatic representation of the Marietta process using compressed air to replace diminished natural-gas pressure for the purpose of restimulating the flow of petroleum from seemingly exhausted or nearly exhausted oil sands. The compressd air serves to force the oil away from the zone of air pressure and toward the intakes of the oil pumps when the overlying rock formation acts as an imprisoning barrier above the air.



© Schlueter, Houston, Texas.

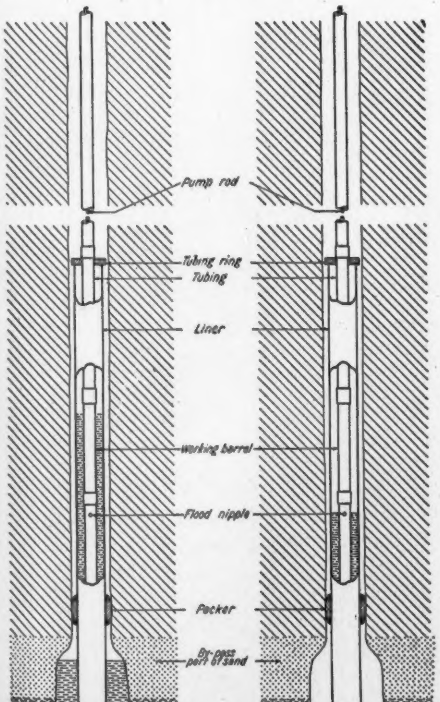
This great pool of mirrowing oil does not suggest that our underground store of petroleum may soon be exhausted. Nevertheless our lack of covered storage facilities is costing us vast losses annually through evaporation.

rious expedients have been resorted to in order to promote this transition artificially, and in this work the compressor has given the most encouraging results.

Pressure may be applied from agencies at the surface through the medium of air or natural gas, or the subterranean pressure may, in effect, be augmented by a reversal of the compressor, i. e., inducing a partial vacuum. In some districts this latter procedure has answered quite successfully, but there are oil-bearing areas where the subterranean conditions do not lend themselves to a satisfactory operation of this system. To meet the latter circumstances a subsurface pressure must be built up by mechanical means to replace the pressure originally exerted by the pent-up gas.

In certain fields gas is tapped from the sand a few feet above the oil-producing formation, and this gas is compressed and forced below to again promote the desired movement of the petroleum. This practice has its drawbacks because it not only tends to waste gas but it subsequently lessens the chance of recovering much of the oil which finds its way into the gas sand and not toward the shot holes of the wells. While the yield of a well may be increased considerably by recourse to gas pumping, as just described, the benefits are as a rule but temporary; and this method of stimulation would not be at all profitable if it were not for the greater measure of gasoline that can be obtained from the gas that is thus enriched by contact with the oil. This gas returns to the surface and is drawn off at the casing head for treatment.

Back in 1903, Mr. I. L. Dunn forced gas,



Courtesy, U. S. Bureau of Mines.

Diagram of oil well prepared for maintaining back pressure in it. Left, oil accumulated in the hole. Right, the well after oil has been pumped out.

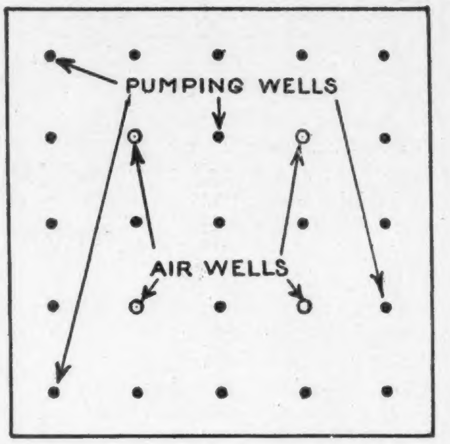


Diagram illustrating an ideal distribution and spacing of both air and pumping wells on a 160-acre tract. It will be noticed that the air wells, indicated by circles, are centrally located in the midst of the pumping wells, shown by dots.

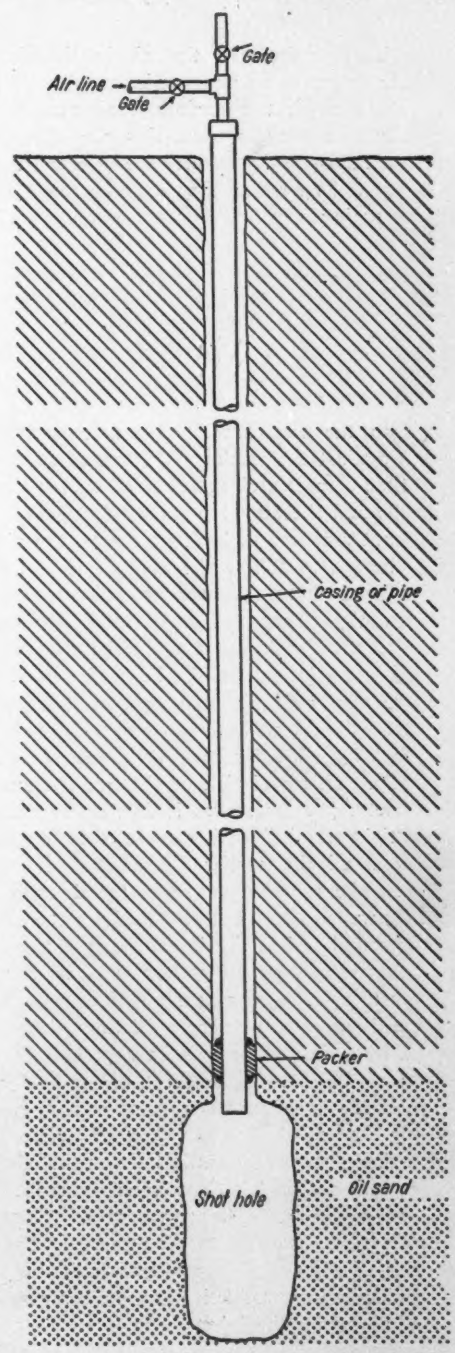
at a pressure of 45 lb. into an oil well in the Macksburg pool, Ohio, which, at the time, was producing from a sand at a depth of 500 feet. At the end of ten days the gas pressure was released, and the pumps were able to bring up a much augmented amount of oil. The output dropped when the gas was exhausted. That experiment was suggestive; but it was not until 1911 that a kindred effort was made elsewhere in the neighborhood of Marietta, when compressed air was substituted for compressed gas. Something like 150,000 cu. ft. of free air was compressed and, at a pressure of 40 lb., was sent underground through one of a group of wells. Inside of a week, oil in amplified quantities was obtained from the adjacent workings. Since then, thousands of wells have been aided by the so-called Smith-Dunn process.

The essential principle is to replace the natural gas which originally accompanied the oil by introducing enough compressed air to provide an expelling medium for the remaining petroleum. The air is forced into the "pay sand" under pressures of from 40 to 300 lb, depending upon local requirements. This air is driven into the subterranean depths through one or more of the wells on a property while oil is pumped in the usual way from the wells surrounding them.

The only equipment beyond that ordinarily employed on an oil lease consists of an air-compressor plant, a system of piping to carry the compressed air to the "air-wells," and, of course, the fittings by which the latter wells are prepared for the reception of the air. The compressors can be of any efficient type, and in size these apparatus range from 20 to 100 horse-power. The air is distributed through 2-in. or 4-in. mains tapped by 1-in. laterals which lead to the air wells. Where compressed air is available it can be utilized as a source of energy for nearly all purposes, and for this reason will greatly simplify the operative plant.

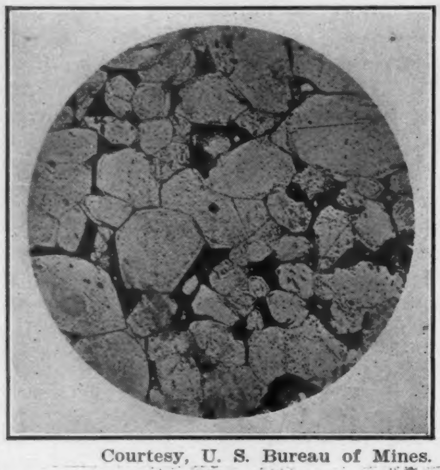
The oil-gathering facilities are of the familiar sort; and the adoption of compressed air, by reducing the number of pumping wells, lessens the total amount of well machinery. The essential fittings in an air well are composed of a tube of 1-in. or 2-in. piping, reaching downward from the surface to the top of the oil-bearing sand, and of a "packer" which is properly secured at a point above the shot hole. This arrangement serves to so seal a well that the air cannot find a ready avenue of escape around the tube, but will be forced laterally from the discharge end of the pipe in a steadily widening zone into the productive sand. In preparing an air well great care must be exercised to make sure that the compressed air shall not have access to any formations other than the oil sands. If this precaution be not taken large quantities of air will be apt to penetrate into barren strata and be wasted.

One can easily realize that some provision may be required to prevent the compressed air from taking a short cut, so to speak, to the casings and outlets of the pumping wells, for there



Courtesy, U. S. Bureau of Mines.

Diagram of a shallow well equipped for taking compressed air.



Courtesy, U. S. Bureau of Mines.

Enlargement of a well-cemented sand stone, showing the nature of the pores through which the petroleum moves.

might be conditions of the oil in the shot holes, lowness, for instance, which would allow the air to reach the surface unobstructedly. Therefore, to guard against this contingency, it is not infrequently the practice to equip the pumping wells so that they may be made to help in maintaining back pressures on the oil sand. While this can be done in a number of ways the simplest one is to place a reducing valve on the gas-gathering line connected with the casing head. However, the underground pressure can be best regulated and sustained by sealing the formations immediately above the oil sand so that gas in them will not have access to the well bore. This arrangement guards against the wastage of gas and at the same time creates a closed circuit between the air wells and the pumping wells.

Without recourse to back pressures, the air would be apt to follow the path of least resistance and therefore pass around and not affect the tighter areas of the oil sand. By the employment of back pressures in the pumping wells, on the other hand, the underground pressure may be built up progressively, and eventually the air will penetrate every part of the sand no matter where it is introduced originally. This evolution of the Smith-Dunn or Marietta process makes it feasible to deal with "tight sands," and therefore to overcome one of the earlier limitations of the system. The recent trend is in the direction of using wells in "open sands" to force the air below ground and to do the pumping at those wells that have tapped tight sands. The reason for this is that less air and lower pressures will suffice to overcome frictional losses and to urge the oil toward the shot holes or intakes of the pumping wells.

The Marietta method is not, of course, invariably successful, but Mr. J. O. Lewis, of the U. S. Bureau of Mines has stated that the compressed air installations amply justified their outlay in fully 80 per cent of those cases that were brought to his attention. The majority of the wells so equipped had fallen to a decidedly low productive figure when compressed air was utilized, but the results were of a highly encouraging and suggestive character. For instance, on one property, where the production was down to less than 200 barrels a year, the output was increased to 2,000 barrels a twelvemonth by compressed air. This particular property had never before yielded more than 1,500 barrels annually.

In another case the production was raised from 450 barrels a month to 1,160 barrels, and the general average for a number of years was held far above that which had prevailed for some time before compressed air was made use of. According to Mr. Lewis: "The records of 32 properties, including several where the process was only partly successful, give an average increase of three and one-half times the production at the time the process was started, this increase being sustained for periods of several months or more." Further, this authority says: "As the operating expenses usually are not increased proportionately with the oil production, profits show a relatively greater increase than production.

"On some of the properties where the process was installed the yields had so closely approached the economic minimum that producing was profitable only during the periods of most favorable market conditions. Favorable results from the process have kept many wells from being abandoned, and caused the rejuvenation of old wells which had been abandoned." Finally, he declares: "On the whole the future is more hopeful than the present results indicate because the process is so new that there are many possibilities of increasing its efficiency."

No details have yet been published that make it clear that the Smith-Dunn process can be used to advantage in wells that have not reached a low state of production, but experience in one direction would seem to point toward its beneficial employment while wells are yielding at a good rate. In the Cushing field, in Oklahoma, the accidental admission to an oil sand of high-pressure gas from a deeper stratum temporarily greatly increased the flow of a well which previously was giving about 50 barrels daily.

We are informed by the U. S. Bureau of Mines, that there is no reason why the Smith-Dunn process should not be equally effective in the forcing of oil from the sand when natural gas is substituted for compressed air—mechanical compression, of course, being essential. The principal advantages claimed for the utilization of compressed natural gas are: The gas recovered from the pumping wells will not be diluted with air or its fuel value decreased; dangerous mixtures of air and gas could not be formed; on properties where natural gas could be had in sufficient volume and under high enough pressure no compressor plant would be needed; and at times the exhaust gas from gasoline compressor plants could be employed without further compression.

However, the choice between natural gas and air will ordinarily be decided in favor of the latter owing to the fact that natural gas will often not be available or can be had only at prices which would make its use for this service prohibitive. The operative method or cycle in either case would be substantially the same. If the natural gas is not already under pressure, it would have to be dealt with

Courtesy, U. S. Bureau of Mines.

An enlarged section of Trenton limestone, illustrating the character of the pores.

by a compressor plant. By carefully gathering the return gas and putting it through the compressor again, it may be circulated in a closed circuit. Of course, there is apt to be wastage underground and also at the surface, and some of the gas may be used for fuel. By heedful operation the wastage should not be large. In the early life of an oil field, when much natural gas is obtained with the oil, it might be well worth while to save the gas and to force it back into the oil sand—in this way both accelerating and augmenting the recovery of petroleum.

It is a matter of much interest to learn that the use of compressed air does not give any trouble by reason of an increased deposition of paraffin in the sands. In fact, in many instances, the augmented pressures brought about by the air have actually forced much waxy material from the wells. Some oil men have feared that the expanding and cooling action of the air would stimulate deposits of clogging paraffin. However, the compressed air fortunately serves to force the paraffin out instead of letting it accumulate in the pores of the sands as normally occurs under weak gas pressures. In short, the presence of the air, under pressure in the sand, facilitates the adoption of methods for removing the paraffin from the sand about the shot hole which ordinarily could not be brought into play.

From what has been said it should be evident that the effectiveness of this promising system is largely contingent upon the nature of the geological formation of the oil field and the absence of faults or fissures which would permit the escape of the compressed air before that medium reached the stage where it might be instrumental in stimulating the desired movement of the oil. Up to a point, the oil operator works very much in the dark, and whether or not his well will pay for the drilling depends upon the position of the oil sand, its character, and its relation to adjacent gas and neighboring water, not to mention the disposition of the superposed rock. True, the log of the well should disclose the constitution and extent of the several strata pierced by the drill in its descent, and the logs of several near-by wells should afford a still better index of the sub-

surface makeup of the earth's crust. But this data alone will not tell the story necessarily of the forces at work which play a prime part in driving the oil from point to point and in impeding or promoting its recovery by man.

The scientist has latterly done something to lessen the prospector's groping, and Mr. R. Van A. Mills, of the U. S. Bureau of Mines, has devised an experimental apparatus, a metal tank or box glazed in front with heavy plate glass, which makes it practicable to reproduce on a small scale some of nature's subterranean processes. (See Fig. pp. 10204). It is feasible to arrange sand, oil, and water in various strata, and then to subject them to air pressure so that the shifting of the oil, water, and air within the sand can be made to approximate closely just what occurs in an oil field when the oil sand is tapped and the gas is permitted to escape surfaceward.

In fact, either pneumatic or hydrostatic pressures can be modified at will to bring about changing relations of the intermixed materials and liquids. Further, the oil sand, the clay, the gravel, etc., can be packed or tamped to duplicate in miniature the geological formations that bear directly upon the possible migration and reclamation of the petroleum. Indeed, the researcher can bring into play different chemical reagents which will cause a cementation that produces a rock-like structure or artificial sandstone.

The largest of these testing tanks has a capacity of nearly 80 gallons and measures 72.24 by 48.82 by 5.24 in. The top and front can be removed to facilitate the preparation for an experiment. Along the top, the ends, and the bottom are a number of cocks and connections, through which water, oil, gas or air can be admitted and drawn off. The top connections are commonly used to represent neighboring wells; and they permit the investigator to simulate field conditions—such, for example, as the employment of the Smith-Dunn or Marietta compressed-air process.

Mr. Mills' laboratory work has revealed that compressed air can undoubtedly be counted upon to cause the migration of entrapped oil so that it will reach the intakes of pumping wells; and his purpose is to carry a tank right to the oil field and there reproduce on a small but suitable scale the circumstances prevailing underground. In this way, he and his confreres are confident that much can be done towards bringing about a fuller recovery of the petroleum and, withal, a wiser and more profitable exploitation of our oil fields. As he has pointed out, it is only by studying the movements that take place far under ground, and the manner in which the fluids shift and react upon one another, that the hidden oil can be jockeyed, so to speak—nature's forces counterbalanced or skilfully disturbed—and the oil made to flow to desired points from which it can be raised to the surface.

Owing to the heavy plate-glass front of the tank, it is possible to see every change that takes place and it is also quite easy to photograph them at intervals so as to have a complete record of the start and finish of the visible phenomena involved. Finally, by altering the air pressure—which may represent either gas or compressed air, the man of research may simulate to a nicety subterranean actions and determine, the while, just what force should be brought into play to induce the deep-seated oil to travel through intervening sands, to hold water at bay, and to lead, as it were, the petroleum to the suction of the pumps.

LIQUID AIR AND EXPLOSIVES USED TO EXPAND BOLTS

Two experiments comprising immersion in liquid air and an internal explosion are being tried by the Bureau of Standards to ascertain the value of these methods for keeping expansion bolts firmly in place according to *Popular Mechanics*. During the liquid-air process, the bolt is immersed until it has contracted sufficiently to permit its entry into the cavity provided. As it warms, it returns to its former size and consequently jams tightly in place. The average unit frictional resistance on cylindrical pins used in the tests was 2,150 lb. per square inch; with tapered bolts greater tightness was obtained. The second, or explosion, process consists in boring the axis of the bolt shank and exploding a charge within the bore. The tightness in this case will be proportionate to the size of the hole bored in the shank.

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A steady flow of liquid wealth. Year by year we depend more and more upon petroleum as a source of motive energy, lubricants, and essential derivatives.

RADIUM THE UNIQUE

IT IS EXTREMELY difficult for us to realize the actual status of radium in the world or to believe that there are not other astonishing revelations awaiting us concerning it. Some interesting details respecting the supply of radium at the disposal of different countries of Europe and of the world at large are given in an article of the *Berliner Tageblatt,* which at the same time narrates a curious history of certain dealings in radium in Germany during the war. After referring to the report of the new discovery of radium in Madagascar, where it has been found in a new mineral called betafit, and is said to be therein contained to a larger extent than in any other form, the article proceeds: "The world supply of pure radium is not exactly known, for it is distributed in tiny parts of grammes, milligrammes and fractions of milligrammes, over countless clinics, scientific laboratories, and industrial works throughout the world. Statistics which have some claim to accuracy speak, however, of 100 grammes (3½ ounces). The larger part—namely, 60 grammes—is in America, the chief productive soil for radium. The Memorial Hospital in New York possesses the tremendous amount of four grammes. In Europe there are two centers of the highest radium standard—Vienna, which preserves two grammes at the Academy of Sciences, and Paris, which, since Christmas, has concealed the like amount in the cellar of the Radium Institute, conducted by Madame Curie. In order to curb the fiery forces of these two grammes, they are let into a great hollowed stone, which is, moreover, clothed in a mantle of lead 30 centimetres (nearly one foot) thick. This repository of radium is said to resemble an image of Buddha. It is kept in a walled-in safe, which is closed by a heavy iron door. Germany is in a peculiar position. It played a great part in radium research, and possesses in Berlin, Heidelberg and other university towns admirably conducted radium institutes. Nowhere however, has it an undivided quantum equal to that in Vienna or Paris. The total weight of the fractions of radium distributed among the Berlin clinics and institutes has never been actually established, but it is estimated at only one gramme. This quantity, and such supplies as otherwise exist in Germany, are amply sufficient for healing purposes. It is, however, noteworthy that, during the war, and in the time after the war, the stock of radium in Germany was greatly lessened, and the loss has not yet been made up. What was done was done in secret, and belongs to those things which cannot be plainly proved; but in adept circles it is regarded as certain that in the form of radium, whole fortunes were conveyed abroad and concealed within the frontiers.

A cablegram from Commercial Attache Carlton Jackson at Mexico City states that according to official figures Mexican petroleum exports during April amounted to 13,200,000 barrels, a decrease from March, which is attributed in some quarters to manipulation, according to the Commercial Attache.

Compressed air aids in painting San Francisco Furniture Exchange Building.

NEW BUILDING PAINTED BY AIR SPRAY

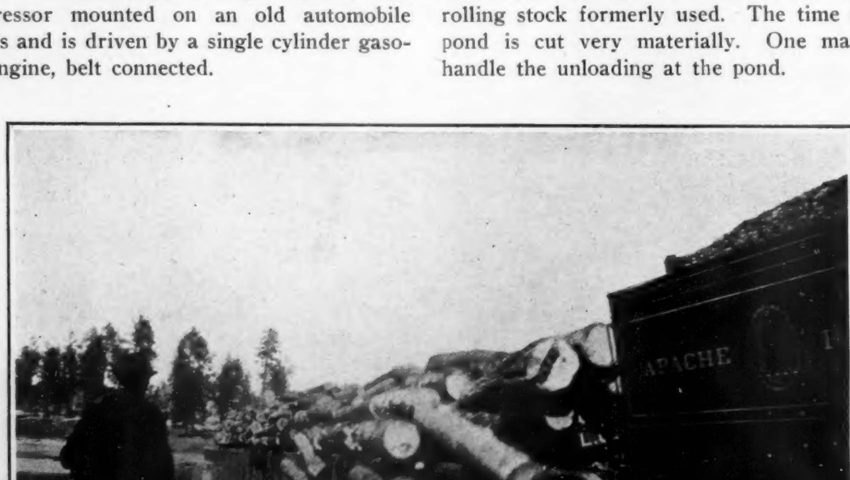
THE accompanying illustration shows the method employed in painting the new building of the San Francisco Furniture Exchange, the second largest building of its kind in the United States. The building is 160 by 140 feet and eight stories in height. By means of compressed air, two men and a foreman painted the entire front of the building in a day and a half. Each painter paints a strip about 12 ft. wide, about 6 gals. being used on each strip. The paint container is carried on the platform and has a capacity of about 13 gals., although it is only filled about half full. This system of painting has been found by the contractor, Mr. Henry Mohre, to be the most efficient and the most desirable method of doing such work.

Air is furnished by a single cylinder air compressor mounted on an old automobile chassis and is driven by a single cylinder gasoline engine, belt connected.

UNLOADING LOGS WITH COMPRESSED AIR

A SPECIAL device that is proving of great service in logging operations makes it possible to unload eighteen cars of logs at a pond in six to eight minutes, according to a recent issue in *Scientific American.* When the train is properly spotted at the pond the man in charge of unloading adjusts the lock pins and then gives the engineer the signal to apply the air. The engineer makes a 20-pound application, which operates the device, releasing the stakes on the side next to the pond and allowing the logs to roll freely. The outside rail of the pond track is elevated fifteen inches above the inside rail.

The stakes are then put back in place, the lock pin replaced, and the car is then ready to load. One company in Arizona that uses this device now operate with just one-half the rolling stock formerly used. The time at the pond is cut very materially. One man can handle the unloading at the pond.



Unloading logs with compressed air.

Michigan Sweetens It

Something About the State's Place in Sugar Making; Process, Plant Facilities, Money Invested and Distribution

By HOWARD CAMPBELL

DO YOU know how sugar is produced from the cane or beet?

It is a simple yet interesting process. The article entitled "Michigan Sweetens It," by Mr. Howard Campbell, in a recent issue of "The Michigan Manufacturer and Financial Record," tells the story so clearly that we extract from it. In addition we show some illustrations of the condensers, evaporators and vacuum pumps (which are in reality air compressors reversed.)

To handle the water, juices, and syrups, pumps and yet more pumps are required. For this service the modern centrifugal is now the general favorite on account of its compact and rugged construction.

This centrifugal pump should not, however, be confused with the centrifugal which Mr. Campbell describes for separating the syrup from the granulated sugar.

SUCHROSE, or sugar, is found in a large variety of plants, but is so apt to be accompanied by the characteristic flavor of the plant or other carbohydrates, such as starch or glucose, that unless it appears in relatively large proportions and can be successfully freed from the taint, it does not pay commercially to extract it. For its supply of sugar the world is dependent largely today on sugar cane and the sugar beet.

Unlike the cane, the sugar beet reaches its highest development in a north temperate climate, such as exists in Michigan.

The planting of sugar beet seed takes place in the month of May, a planter being used which drills four solid rows of seeds into the ground at each trip across the field. When the plants are about two inches high they are "thinned," this operation being the removal of all except one every six or eight inches. The beets are ready for harvesting about the middle of September, being gathered usually about the time the first frosts come. When suitable for harvesting, the beets are loosened from the ground by means of a puller, picked or "pulled" by hand, "topped," loaded into wagons and brought to the factory or transferred to railroad cars as the case may be. The operation of "topping" consists of removing the beet top, or leaves, with a heavy knife.

The beets are unloaded in the beet shed, where they are thrown into huge bins with sloping walls, at the bottom of which are flumes or sluices provided with board covers. These covers are made in short sections so that they can be easily removed as the beets are fed into the flume. The beets are conveyed into the plant by floating them in the current of water which runs swiftly through the flume.

As the beets enter the factory they are caught up by a bucket conveyor and dumped into the washing tank, which holds approximately half a carload. Through the center of the tank is a shaft to which are attached a number of paddles which stir the beets as the shaft revolves, thus cleaning off practically all the dirt.

On reaching the outlet end of the washer, the beets are thrown on to a belt conveyor, which carries them along very slowly, so that all weeds, sticks and other refuse can be picked out. The belt spills the beets into the buckets of a flight conveyor, which carries them to the top floor, where they are dumped into a hopper through which they pour on to an automatic scale. When 1,000 pounds have been received on the scale, the bottom of the hopper closes automatically and the beets are dumped into the slicing machine. The scale registers every 1,000 pounds of beets, thus keeping a record of the amount sliced.

The construction of a "beet slicer" is based on the well-known design of a horizontally revolving cutter plate. The machine is approximately ten feet high and eight feet in diameter at the base, where the cutter plate is located. The blades, which are about six and a half inches long, are arranged about the edge of the cutter plate, and the hopper is so made that the beets fall on the knives, those at the bottom being held against the knives by the weight of the mass above. The cutter plate revolves at a rate of 45 revolutions a minute, slicing the beets into long, narrow, thin strips called by their French name, cossettes. The cossettes pass under the disc and are received in a round box from which they are pushed out through a spout on to an endless conveyor belt which carries them to the diffusion battery.

A diffusion cell resembles a tank, being approximately seven feet high and five feet in diameter, and holds three tons of cossettes. When ready for operation the cossettes are dumped or fed into the cell through a manhole in the top. The cell is filled up to about ten inches from the top, then warm water at about 140 degrees temperature is turned in until the cell is full. This warm water extracts the juice containing the sugar from the cossettes by a process of "osmosis."

When two liquids which, when mixed, do not produce chemical change, are brought in contact and allowed to stand, they mix uniformly without the application of mechanical impulsion or chemical force. Such action is called diffusion. The same action takes place even when two liquids are separated by a membrane, which is simply a fine network of plant or animal tissues. Diffusion through a membrane is called "membrane diffusion," or osmosis. Membrane diffusion may be illustrated by a simple experiment. Fill a sack with a sugar solution and surround it with water in a vessel. After a time an interchange will take place between the solution within the sack and the water surrounding it, the sugar passing out of the sack as the water passes in. This is the action that takes place with each cossette, and as the cossettes are very thin, practically all of the juice is extracted from them in from six to eight minutes.

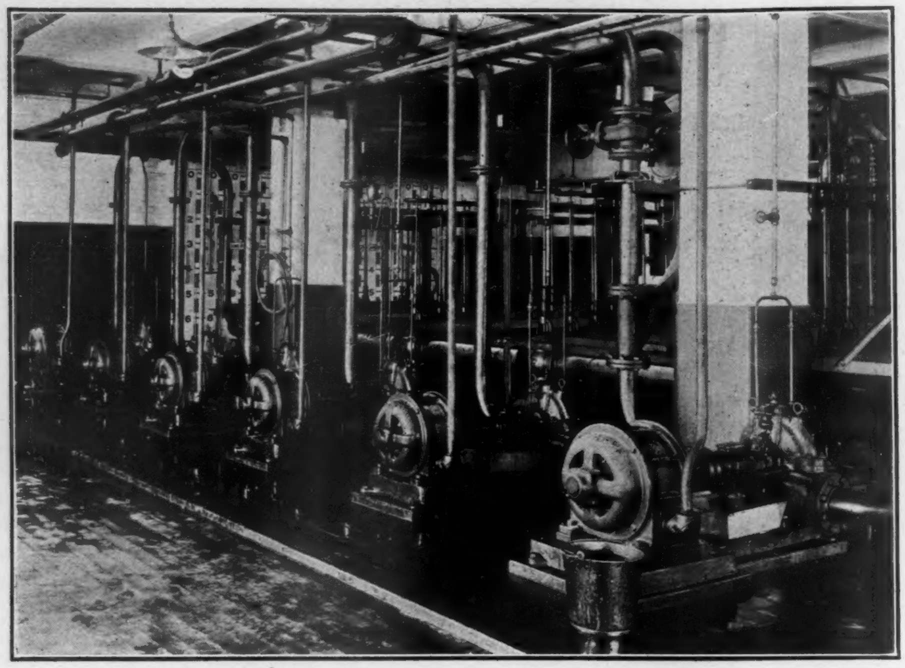
When this time is up the juice is drawn out of the cell through a calorisator, or heater, and into the next cell. The "battery," as it is called, contains fourteen cells; therefore, it is obvious that as the juice circulates it increases in density. After it has passed through a number of cells, its density becomes the same as that of normal juice. At this point it is drawn off into the measuring tank, where a record is kept of the amount of juice obtained. From here it passes to the reserve tank.

The next process is that of carbonation. The sugar solution, known as the "diffusion juice," is almost as black as ink as it comes from the diffusion battery, and therefore must be clarified. This clarification takes place in a "carbonation tank," of which there are six.

A carbonation tank, or "carbonator," is about seven feet wide by fourteen feet high In the bottom of the tank is a coil of steam pipes for heating the juice and a system of perforated pipes through which carbon dioxide gas is admitted at the proper time. The tank is filled about half full of juice and a certain amount of lime added. The lime sterilizes the juice, precipitating the impurities and killing all the germs which have been introduced from the soil, water, air and other agencies. Carbon dioxide gas is now admitted under pressure, which precipitates the lime, carrying with it the impurities that were in the juice. The juice has to be watched very closely and frequent tests made to determine the point at which the operation should be terminated, although the usual time is about twelve minutes.

Fertilizer a By-Product

When the juice leaves the first carbonation process it contains a certain amount of precipitate of calcium carbonate, which must be removed before it can be subjected to the second carbonation. Therefore, it has to pass through the filter press. A filter press is a series of cast iron plates containing a number



Battery of six Cameron centrifugal pumps installed in the Revere Sugar Company, Boston, Mass.

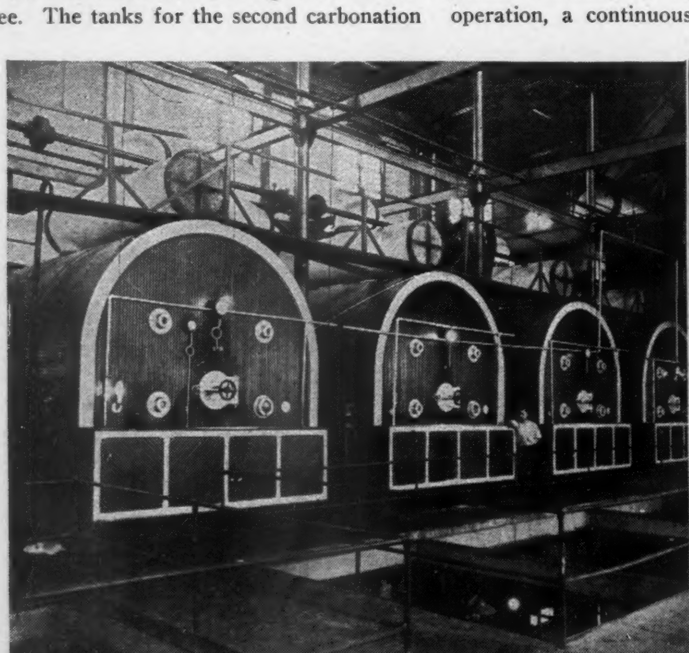
of long slots, with corresponding frames. A double thickness of duck and burlap is stretched over these slots and the juice is forced through, leaving lime precipitates within the frame. As more juice is filtered, the lime collects until it has formed a cake, which is then removed and later is used for making fertilizer.

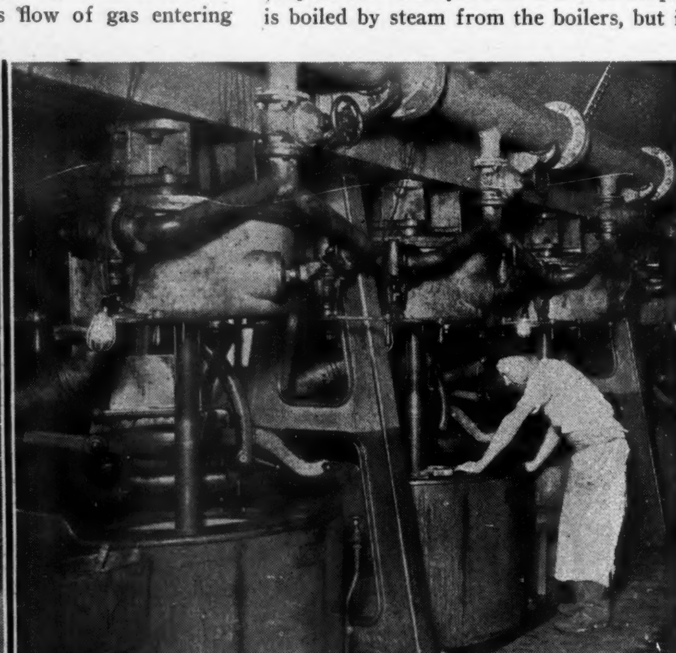
The filtered juice, which now is clear and slightly yellow, passes to the second carbonation, which is practically the same as the first, more lime and more carbon dioxide gas being added. The second carbonation not only reduces the alkalinity but improves the juice as in the first carbonation, though in a smaller degree. The tanks for the second carbonation are constructed exactly the same as those for the first. Here the juice is tested every few seconds until the alkalinity is down to the required point, then the gas-valve is closed and the steam turned on until the temperature of the juice is up to 100 degrees F., in order to break up acid calcium carbonate formations. When the carbonation and heating are completed, the juice is pumped to the second filter press. The second filtration process is the same as the first.

After the second filtration the juice is sent to the sulphuring tanks, through which it passes in a continuous stream. Instead of carbon dioxide gas, sulphur gas is used in this operation, a continuous flow of gas entering the tank and a continuous flow of juice passing through it. This sulphuring process not only further reduces the alkalinity of the juice but also has a decolorizing effect, precipitates such lime as was not precipitated by the carbon dioxide gas, facilitates the crystallization of sugar from the juice, removes a considerable quantity of nitrogen compounds, and the sugar obtained has a better keeping quality, due to the antiseptic property of sulphurous acid. The proper alkalinity of the juice after this third carbonation should be about 1-100 per cent. The alkalinity is regulated by the speed with which the juice is allowed to flow through the tank. The faster the juice flows, the higher the alkalinity, and vice versa. A small amount of soda is also added in this process, and the juice is heated again before passing to the third filter press. The filtration process is the same as before, and then the juice is pumped into the supply tank, from which it is drawn as required for the evaporation process.

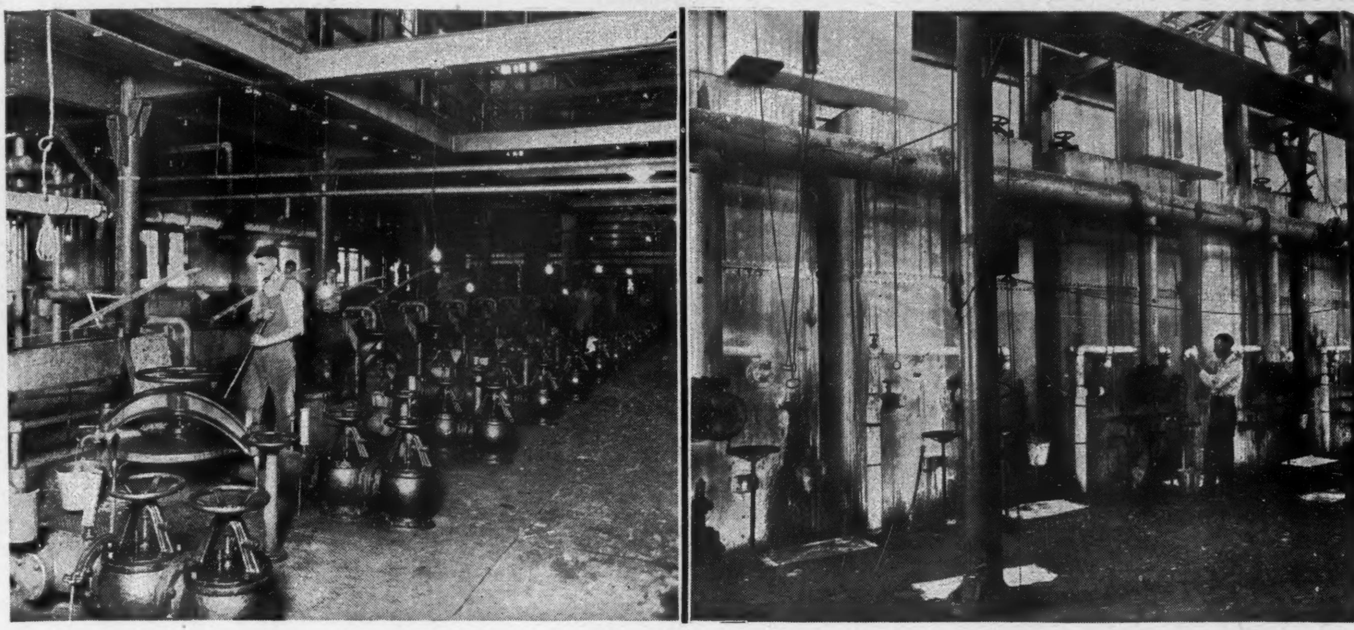
There are four of these evaporators, through which the juice passes consecutively. This operation is necessary before the juice is boiled, because (1) the juice contains too large a quantity of water and requires too long a time for boiling down in a vacuum boiler; (2) the juice contains a considerable quantity of substances which separate from the solution when boiled down to a syrupy condition and should be removed by filtration before further concentration, as they would otherwise increase the ash content of white granulated sugar; (3) the alkalinity of the juice should be corrected to the proper degree, since too high alkalinity renders the crystallization of the juice difficult.

The juice enters the first evaporator under slight pressure and passes into a series of copper tubes, of which there are 1,100 in an evaporator. The juice in the first evaporator is boiled by steam from the boilers, but in the





Sugar manufacture in the factory of the Mount Clemens Sugar Company. At the left is shown a set of evaporators. The syrup is boiled under a vacuum in each tank in turn. At the right are shown some of the centrifugal machines, where the moisture is literally spun out of the syrup, leaving the clean, white sugar in the machine.



Further operations in the Mount Clemens Sugar plant. At the left a workman is shown loading a diffusion cell with sliced beets. The cells are below the floor. At the right is a view of the carbonation tanks. Here the impurities in the syrup are precipitated.

second evaporator it is boiled by the vapor from the juice in the first one, and each succeeding evaporator is boiled in the same manner—by the vapor from the preceding one. A steam of any temperature can evaporate a fluid whose boiling point is lower than the temperature of the steam. Steam developed by a certain temperature has the same temperature as that of the fluid from which it has been developed, so long as both remain under the same pressure; hence, in order to evaporate the juice in each tank with the vapor from the preceding tank, the pressure must be lowered. This is done with an air-pump, a vacuum being created in each tank, which, of course, lowers the pressure. A greater vacuum is created in each succeeding tank, thus making it possible for the juice to boil at a lower temperature in each tank in turn, becoming cooler and thicker as it passes toward the last tank. When it enters the evaporating process the syrup contains approximately 90 per cent water. It leaves the last evaporator in the form of a thick, transparent, yellow syrup containing about 30 per cent water.

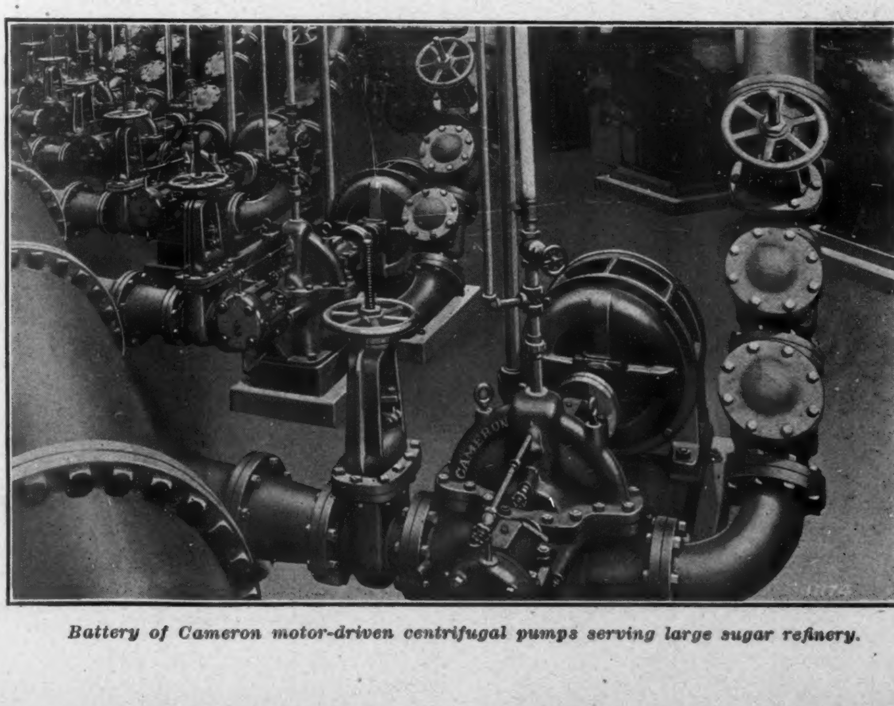
As the juice became thicker by evaporation, the percentage of alkalinity increased; therefore, it has to be subjected to another sulphuring process before it is ready to boil into sugar. This process reduces the alkalinity to a minimum and precipitates the impurities, which, in the form of lime salts, are now removed in another filtering operation. The thick, clear juice obtained from the filter presses is now sent to the supply tank, from which it is drawn for boiling in the vacuum pans.

Boiling the Syrup

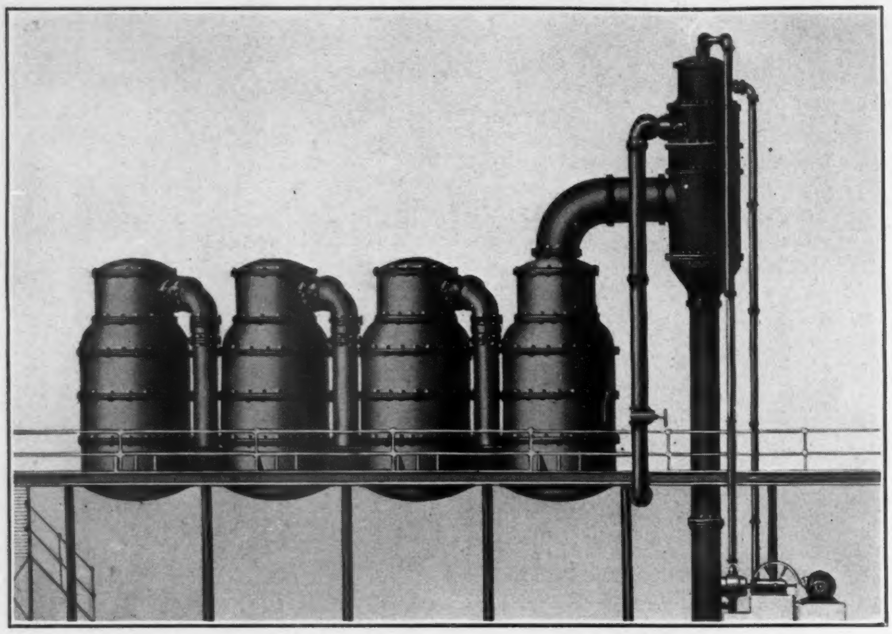
In the early history of the industry, sugar was boiled in open pans over a direct flame or by heating with steam coils. Sugar crystals produced by boiling in such a pan acquire a brown color, owing to the decomposition of the sugar by high temperature. The fuel consumption is also much greater in the open pan process than in the more modern system. For these reasons the open pan was abandoned and a large tank used in which the pressure could be diminished by means of an air-pump and a condenser. These tanks are about fifteen feet high by twelve feet in diameter and each contains a series of copper steam coils for heating the syrup. A vacuum is created in the tank which makes it possible to boil the syrup at 150 degrees F.

The first operation in the process of boiling the syrup is to draw juice into the pan, or tank, until it is about one-third full. It is then boiled until fine crystals, or sugar-grains, begin to appear. This has to be watched closely and a test taken every few minutes. When the sugar begins to "grain," an additional amount of juice is added and the boiling proceeds, the new juice adding to the size of the grains. After the grains form from the first lot of juice, additional juice, instead of forming new grains, increases the size of those already formed. The business of sugar boiling, knowing how much juice to draw into the tank and the correct size of the grain on which to "build," can be learned only by actual experience under the direction of an expert sugar man.

Juice is now added in the correct quantities and at the proper intervals so that by the time the tank is full the crystals will be of the correct size. The amount of juice added each time should be small enough so that the excess of water will be evaporated in the least possible time. If too much is added there is danger that the mass will be rendered so thin as to dissolve the crystals already formed. When the mass in the pan becomes so condensed that a proof placed on a glass plate will not flow away, the boiling is completed, the operation taking about four hours. The product is now a heavy, sugary syrup called fillmass



Battery of Cameron motor-driven centrifugal pumps serving large sugar refinery.

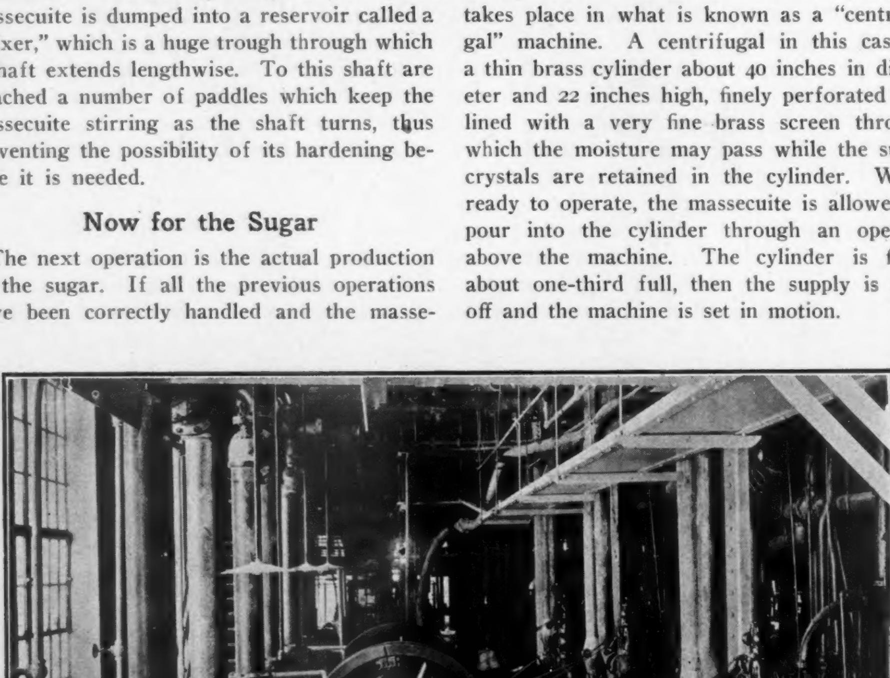


Counter-current barometric condensing plant serving quadruple effect.

(German) or massecuite (French), and contains about 93 per cent. solids and seven per cent. water. The boiling being completed, the massecuite is dumped into a reservoir called a "mixer," which is a huge trough through which a shaft extends lengthwise. To this shaft are attached a number of paddles which keep the massecuite stirring as the shaft turns, thus preventing the possibility of its hardening before it is needed.

Now for the Sugar

The next operation is the actual production of the sugar. If all the previous operations have been correctly handled and the massecuite has been properly boiled down, the separation of the sugar crystals from the syrup will present no difficulties. This separation takes place in what is known as a "centrifugal" machine. A centrifugal in this case is a thin brass cylinder about 40 inches in diameter and 22 inches high, finely perforated and lined with a very fine brass screen through which the moisture may pass while the sugar crystals are retained in the cylinder. When ready to operate, the massecuite is allowed to pour into the cylinder through an opening above the machine. The cylinder is filled about one-third full, then the supply is shut off and the machine is set in motion.



Three vacuum pumps, at American Beet Sugar Co., Oxnard, Calif.

The cylinder, which stands upright, is driven by a vertical shaft which operates with a water motor and spins at the rate of approximately 1,800 revolutions a minute. The centrifugal force drives the mass against the wall of the cylinder and forces the syrup out through the fine holes in the screen, while the sugar crystals remain packed against the wall. When the centrifugal is stopped, it contains a lot of clean white sugar in place of the dark brown mass which was poured into it about four minutes before.

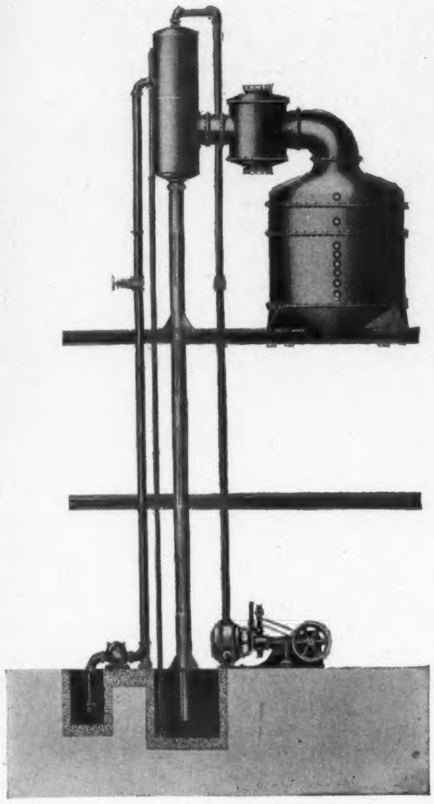
The syrup which is spun out through the wall of the cylinder is called "green syrup." This is caught by the iron shell which encloses the cylinder, and collects at the bottom, where it flows through a spout into the green syrup tank. A fine spray of water is played over the surface of the sugar before the machine is stopped, to remove the last trace of syrup from the sugar crystals, the syrup spout being shifted to a wash syrup trough before the spraying commences so that the wash syrup may be stored in a separate tank. This wash syrup is afterward used for boiling white sugar mixed with thick juice. The "green syrup" eventually is returned to another vacuum pan, where it is made into brown sugar. Brown sugar is boiled down in a manner similar to the treatment of white sugar syrup, and passes through the same centrifugal process.

The white sugar is dumped through an opening in the bottom of the centrifugal machine, where it falls into a conveyor trough and is carried into the granulator, which is a drum about seven feet in diameter and approximately thirty feet long, slightly inclined so that the sugar will work toward the outlet end, and containing a great many little shelves. The granulator is slowly revolved by means of a wheel gear, picking up the sugar on these shelves and carrying it toward the top. As each shelf nears the top in its circular travel, the sugar falls off, with the result that the air is constantly full of falling sugar. A warm air blast is directed through the granulator and before the sugar has completed its journey through the machine it is thoroughly dried and granulated.

From the granulator the sugar pours into a large bin which supplies the packing room. Up to the last year or so, sugar was always packed in barrels, but the streak of economy which hit the rest of the country has also hit the sugar manufacturer, and this year they are packing it in bags. Automatic machinery makes it possible to fill a 100-pound bag, weigh it and sew it across the end in a minute and a half.

The sulphur used in the sulphuring process is burned at the mill, about 400 pounds of sulphur being used daily. Approximately a carload of lime rock is used daily to furnish lime for the carbonation processes and also to make the carbon dioxide gas which is used in the same operation.

After the juice is diffused from the cossettes, they are reduced to a mass of soft pulp which is dried and sold for cattle feed. This dried pulp is worth about $50 a ton.



Counter-current barometric condensing plant serving vacuum pan.

The Industry in Michigan

The first sugar factory in Michigan was built at Bay City in the fall of 1898. This was erected by a corporation known as the Michigan Sugar Company, but was not the same company as that which is organized under that name at the present time. Later the Bay City Sugar Company was organized and built factories at other points in the state. The original Michigan Sugar Company later moved its factory and equipment West and a new company was formed which included the Bay City Sugar Company, incorporating under the name of the Michigan Sugar Company. This company is now the largest in the state, with factories at Alma, Bay City, Caro, Croswell, Saginaw and Sebewaing. The Caro factory is the largest in the state, producing 325,000 pounds of sugar every twenty-four hours. Eight other companies have also been formed, with factories located at Bay City, Mount Pleasant, Owosso, Holland, St. Louis, West Bay City, Mount Clemens, Marine City, Menominee and Blissfield, making a total of seventeen factories in the state.

The industry has grown to such proportions that the sugar companies pay to the farmers an average of more than $10,000,000 annually for their crop of beets. They also pay to the railroads of the state more than $2,000,000 in freight charges. For the operation of these plants, about 250,000 tons of coal are required yearly, most of which is mined in the state. One hundred thousand tons of limestone are also used, all of which is quarried in Michigan.

The seventeen factories turn out 300,000,000 pounds of sugar annually, requiring 480,000 barrels made in Michigan from Michigan material. Fully 50,000 farmers are engaged in raising the beets which these factories consume. The "season" for the sugar factories is only as long as is required to consume the year's crop of beets, which is about 100 days on the average, or three and a half months. During this time the factories run twenty-four hours a day, employing altogether more than 8,000 men.

Most of the output of the Michigan factories is marketed in Michigan, Ohio, Indiana and part of Illinois, although last year some of it went to France as part of the supplies sent by the American Food Administration.

COMPRESSED AIR IN THE WHALING INDUSTRY ..

By C. W. GEIGER

COMPRESSED AIR is playing a very important part in the whaling industry at the present time.

After a whale is captured, compressed air is used to make him float, each whaler being equipped with an air compressor. The whale is tied alongside the ship and a four-foot spear is plunged into his interior. This spar is very sharp at the end and is provided with perforations through which the air escapes. At the butt of the spear there is a compressed air hose attached. About two inches back of this compressed air hose there is attached a heavy rope. The air hose is about 100 feet in length.

After this spear has been rammed into him he is pumped up to a pressure of about 80 inches which makes him float like a rubber ball. The spear is then withdrawn and the hole plugged up with okum. It requires only three or four minutes to deliver sufficient air within the whale to make it float.

In most of the whaling steamers no storage tank is used, the air being delivered direct from the pump, but on the *Hercules* a pressure of 40 pounds is carried in the storage tank.

After the whale has been properly inflated a flagstaff with a flag is mounted on the carcass while the steamer leaves in the pursuit of another whale.

The whaling industry at the present time is so different from the old industry that almost the only point of resemblance is that it deals with whales. Its operations, its products, its whole point of view is vastly different.

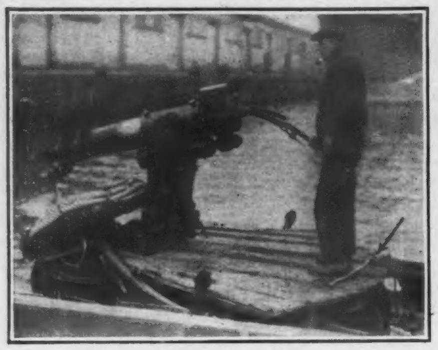
The new whaling is based on the ultilization of the entire carcass, of fishing in shore waters, on a system of capture far more certain than that of the old days and on bringing the entire whale to be cut up and processed at the factory.

From the carcass there is produced not only oil for which the soap industry has provided a new market, but fertilizers of first rate quality, bone meal and whale meal, besides other commodities, so nothing is wasted. The patent packing house saying "Everything is utilized but the squeal" applies in the whaling industry as everything is used but the blow. From this point of view it has opened up a new industry operating along the Pacific Coast, and along California in particular. It is an industry that is already widespread in the world.

The Norwegians who were the first to adopt the new method have whaling stations scattered throughout the Seven Seas, with various companies operating almost from pole to pole. Their investment has grown to considerable proportions from 1912 to the present time.

Following the Norwegians' example plants have been in operation on the Pacific Coast of North America for some time, notably on Grey's Harbor and on Magdalena Bay in Mexico. The plant of the California Sea Pro-

Showing the spear which is used to deliver compressed air into a whale.



The arrow points to the spear which is manipulated from this platform.

ducts Company was the first to be equipped on the coast of California.

Treated by the methods that prevail at this modern whaling station an average whale will yield 1750 gallons of standard whale oil; 2½ tons of whale guano; 1½ tons of bone meal and about 200 pounds of gill bone. Whale oil is now used for the making of glycerine, in cordage works, in tanning leather, for tempering steel; and for many other purposes, but its most important present day use is in the making of soap.

The entire output of whale oil of the California Sea Products Company has been contracted for by a soap manufacturer. There is a peculiar interest in this industry in California.

The ordinary whales of the Pacific are the Hump Backs; the Fin Back; the Sulphur Bottom and the California Gray, all of which seek their food near the coast, follow the season up and down from Mexico to Washington, and in the early summer migrate towards cooler northern waters; in the fall they move southward.

In 1915, the whaling station on Grey's Harbor, 600 miles north of San Francisco captured 340 whales, on each of which it is estimated that they made a net profit of $308. The whaling station at Magdalena Bay, 1,000 miles south of San Francisco, took 575 whales but the active season on Grey's Harbor was limited to 4½ months, and that on Magdalena Bay was no longer. But in the meantime the whales that appear in the sea off the Washington Coast and once off the Mexican coast have traveled twice past the California shore, their leisurely migration up and down covering practically the entire year.

This means that the whale herds move in a continuous procession up and down through California waters the year round. They rarely go more than 100 miles from the shore.

This modern whaling industry with its comparatively short radius of action finds itself more fortunately situated on the California coast than it does further north or south where the visitation of the herds is seasonal, and comes only once a year.

Whaling operations on the Pacific Coast during the year 1919 netted a total of 1,436 whales. This produced 2,107,924 gallons of whale oil, 540,280 gallons of sperm oil, 3,450 tons of fertilizer and 14,000 pounds of whale bone.

DETERMINING DUST IN AIR

IN CONNECTION with the improvement of conditions relating to the health of workers in the mining and metallurgical industries, the Bureau of Mines has co-operated with the U. S. Public Heath Service in determining the amount of injurious dust suspended in the atmosphere, and the results of the investigations are communicated to the *Journal of Industrial Hygiene* (U. S.) for September by S. H. Katz, E. S. Longfellow, and A. C. Fieldner, of the U. S. Bureau of Mines.

The efficiency of the Palmer dust sampler was determined by the use of tobacco smoke and of silica dust. Two methods of testing were used. The first determined efficiency on the basis of the surface of the particles entering the apparatus as compared with the surface leaving, by the use of the Tyndall effect. The second method, based on the weight of dust, used a small laboratory Cottrell precipitator in series with the Palmer washer.

The tests showed: (1) that the Palmer dust sampler retained about 45 per cent. by weight of air-floated silica dust when air was passed through it at the rate of 4 cu. ft. per minute. (2) The surface efficiency with silica dust. measured by the Tyndall effect, was 30 per cent. when the air passed at a rate of 4 cu. ft. per minute, and 20 per cent. at 3 cu. ft. per minute; at 5 cu. ft. per minute, water was carried mechanically from the washer. (3) The efficiency based on numbers of the silica dust particles is probably lower than the surface efficiency. (4) The Palmer apparatus was less than 13 per cent. efficient in retaining tobacco smoke, as measured by the Tyndall effect.

Assuming tobacco smoke particles to be of uniform size, the optical efficiency of less than 13 per cent. should also apply to weight and number efficiency.

ISLAND NAVAL INSPECTION BY SEAPLANE

Airplanes are now utilized for covering wide territories in rapid inspection by naval officers stationed at the Hawaiian Islands. In a recent issue of *Popular Mechanics,* we are told that during a recent tour Rear Admiral Shoemaker completed a roundtrip, sea-by-air route of 236 miles, in two hours 30 minutes, despite the fact that on his return he was obliged to face a heavy wind. A feature of the journey was the fact that constant wireless communication was maintained from shore to plane, enabling the admiral to engage in his routine duties as though he had been in his office at Pearl Harbor. Inspection of isolated territories will increase with the perfection of this service.

KEEP OUT OF BOILERS WHEN STEAM IS ON

The following is to bring to the notice of our readers House Bill No. 95 of the Colorado Legislature.

A Bill for An Act to Regulate the Blowing Off of Steam Boilers. Be it enacted by the General Assembly of the State of Colorado:

Section 1. It shall be unlawful for any railroad company or any person, firm or corporation, using steam boilers, to command, order or permit by themselves or their agents any of their employees to enter any steam boiler, firebox, or smoke chamber thereto, for the purpose of repairing or cleaning the same or for any other purpose *when the same is under steam pressure.*

The italics are ours. There are five more sections to the bill. We would suggest that entrance by way of the manhole should be a misdemeanor, while if through the steam pipe, the feed pipe, the blow-off or the safety valve it should be a felony.

Whaling ship using compressed air as shown in photo.

The Industrial Belgium of Post-War Days

Modern Equipment Figures Largely in Plant Replacements with Compressed Air Machinery Attaining a Highly Important Place in Mill, Mine and Factory—Restoration Measures after War's Ravages

By FRANCIS JUDSON TIETSORT

IN REPLACEMENTS of industrial material and equipment in Belgium today, the most modern of labor-saving and money-saving machinery, calculated to augment production efficiency, is being installed whenever and wherever the proprietors of plants have the credit or cash resources to purchase it. The ingenuity of hundreds of such industrial proprietors was sorely tested following the Armistice and the evacuation of Belgium by the erstwhile conquerors of this plucky and stubborn nation. In common with the French, the Belgians realized that their first move in reconstruction must be to get their industrial wheels turning again.

With many companies the problem of accomplishing a new start in the pursuits of peaceful times was more difficult actually than the founding of an entirely new enterprise. The old established manufacturer, however, wanted to retain the benefits of what is called "good will" in business, and therefore, for reasons of credit, prestige and advertising dignity, he stuck to his old mill site, even though nothing but ruins bearing a name remained.

Some of these proud plants that had records running back several centuries never dreamed of changing either their business addresses or their customary outward business habiliments. They ran up the old house flag over the ruins, called back such of their workmen, foremen and engineers as remained alive, and said in effect:

"Here, men, is what is left to us out of the wreck of what the Germans called 'war.' We are going to stick right here and begin business again at the old stand. We've got to install a lot of new equipment, so while we are about it, let's put in the most effective and economical machinery we can manage to obtain. Let's go!"

They did, and they have been going strong ever since, as the authoritative data which the writer obtained in Brussels, Liege, and other industrial centres fully attested. The Belgian engineer of this generation is a pretty efficient and wide-awake citizen, one was at no pains to discover. He is up-to-date, as far as his financial resources will permit, and he knows all the world's leading makes of machinery equipment, and many of the big men have seen the important installations in other countries.

The Belgian engineer is a believer in the efficiency and convenience of compressed air equipment, as are his fellow engineers throughout Europe, and in the last two years the number of new compressors, central air plants, air tools and air machinery in general that have been installed in Belgium compares very favorably with installations elsewhere in the same period of time.

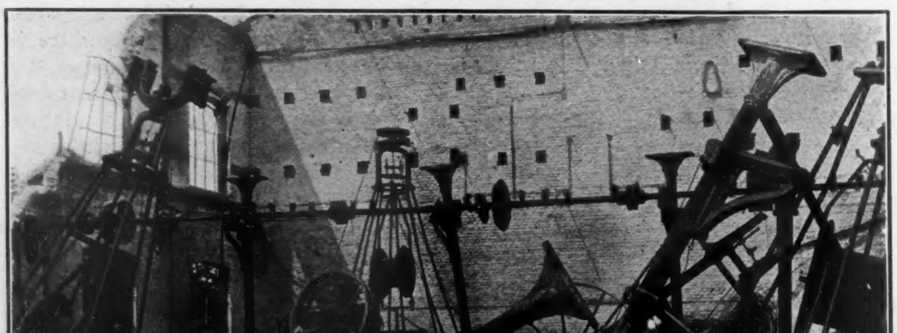
In the course of the writer's recent examination into the industrial aspects of post-war Belgium, he even found that varieties of compressed air machinery which previously had never found a place in Belgian mills and factories and mines, were now being purchased and set up, and with gratifying results. Industrial plant production managers are learning with satisfaction what can be accomplished by means of a central compressed air power plant, with air piped in tight lines to all parts of the works to operate tools, hoists and a wide variety of apparatus.

As a result, just as is the case in France and England and Italy and Spain, one finds that the Belgian quarries, mines, railways, factories, steel mills, chemical works, distilleries (if you remember that word) shipyards, textile works and other plants are turning more and more

Coke ovens at John Cockerill works, Liege, Belgium.

to compressed air, as the way out of many a perplexing problem under the new conditions. One installation of air equipment in a neighborhood is followed by another when the simplicity and efficiency of the particular application have been tested.

By train, automobile, airplane, horse-drawn vehicle and on foot, I had the privilege of traversing the entire depth and width of Belgium on behalf of this magazine, including its largest cities, its blood-soaked Flanders fields where poppies grow, and where too truly the crosses mark the resting places of countless thousands of gallant men, "row on row." The immortal lines of Lieut. Col. John McCrae, Canadian physician, poet and soldier, who gave his own life on Flanders fields, have a poignant significance for the traveler who journeys down from Ostend to Ypres via Couckelaere, the remains of the Forest of D'Houthulst, Poelcappelle and Langemarck, and who returns to the coast through Nieuport and Westende. One simply marvels how a people could pass through such a fiery furnace of destruction and survive to proceed with the affairs of peace with any semblance of "normalcy." Before visiting these scenes of ruin and desolation I had consumed my full share of published descriptions of the war's devastating effects in Flanders, but all the articles and books and descriptive letters of war days and afterward failed completely to prepare one's mind for the shock of actual contact with such terrible pictures as still remain nakedly before the awe-stricken eye. France itself presents no more depressing sights than are to be viewed on the Flanders battlefields.



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Collection of miscellaneous material ready for shipping away from the works of the Ste Ame Vertongen—Termonde, Belgium.

Where the Germans sorted out demolished machinery at the John Cockerill Works, Liege, Belgium.

One cannot begin to appreciate what is going forward in Belgium today, nor measure the spirit of her people, whether lowly or great, nor comprehend what must have been their capacity for both suffering and recuperation, until he has traversed those appalling wastes of toothpick remains of once thick forests, shell-ploughed roads, twisted and torn steel tanks, mangled masonry, demolished bridges and railways, destroyed canals and the cluttered metal and trappings of warfare with big guns, gas and all the other unspeakable paraphernalia of the late holocaust. When one has seen it he indeed trembles with the question of whether civilization is really existent and can understand the troubled viewpoints regarding the possibility of another war put forth by Mr. Will Irwin and Mr. H. G. Wells in their latest books.

Yet if one passes from the nightmare of the Flanders battle-fronts back to Brussels, or Antwerp, or Namur, or Liége, he experiences in a twinkling a metamorphosis when viewing Belgium's routine business and social life. It is like a fanciful transition from Gehenna to Paradise. Still Belgium was only temporarily crippled; the country was by no means crushed by the war, either physically or in spirit.

Comparatively speaking, however, Belgium's loss, in useful and productive land, or in urban property, was not of tragic proportions, excepting in an artistic sense. For a time the Government hesitated about even rebuilding a city like Ypres, preferring to let it lay in ruins as a monument. So great was the popular outcry, however, from the townsmen that it has finally been agreed to rebuild it all except the Cloth Hall, the Cathedral, and the Cloister. The government is to construct 20,000 permanent houses in Ypres, and restore roads and the water, gas, and electric systems. Contracts have been let to firms in Ostend, and 2,000 men are at work. I lunched across the street from the ruins of that noble specimen of mediaeval architecture the Cloth Hall, in a large wooden shed used as a public restaurant.

On another corner of the partly cleared central square, not far away, was a familiar Y. M. C. A. hut, where aid, advice and information were distributed alike to residents and tourists. The shed refectory, which would probably accommodate 250 persons at a sitting, was packed with visitors from all parts of the world, with many waiting to obtain refreshment after the long, dusty and jolting ride by motor car across the battlefield roads from Ostend.

Belgian industry suffered from German confiscation of machinery equipment, but as a whole her factories and foundries and mills and mines came off relatively easy by contrast with the ravages endured in northern France. One reason, of course, was that Germany had determined to remain occupant and guardian of Belgium as a vassal state, had her troops

not been driven out by the last victorious advances of the war in 1918.

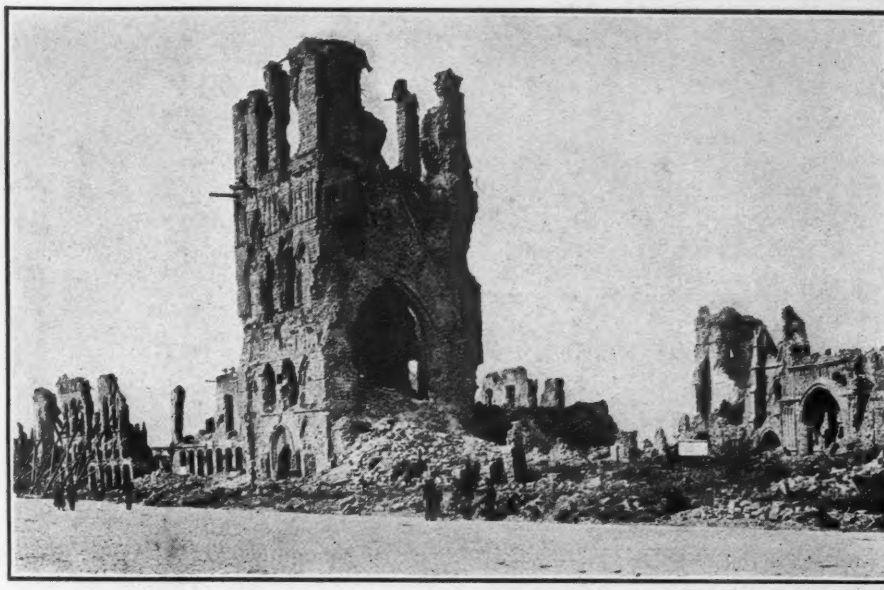
The stubbornly fighting Belgians, including civilians who aroused the fury of German commanders by resisting invasion and by sniping, were shot down without mercy by the troops that overran their peaceful towns and villages, but the Germans had their own reasons for not destroying property having a fundamental economic value, so there was not such a high percentage of "non-military" destruction.

As the issue of the war grew more doubtful in the minds of those at the Kaiser's Great Headquarters, and there came a conviction that ultimate defeat was already a stalking possibility, looting of industrial property increased, as would be natural under the German scheme, but there was not time left to accomplish all that could have been done in the destruction and confiscation of plant machinery.

What the Germans did do, however, in some of the largest and most important engineering works, as will be discovered from the accompanying photographs, was sufficiently complete and painstaking. The German engineers in charge of the destruction or the removal and shipment of machinery to their own country manifestly performed their tasks with meticulous attention to detail. A considerable amount of this looted equipment, or its equivalent, has aready been restored to Belgium by Germany under reparations agreements, but much is still owing individuals in King Albert's kingdom, and the monetary damages still remain to be paid.

At the conclusion of hostilities, when the German troops were marching out, there was much petty confiscation of Belgian property, and soldiers even "requisitioned" door knobs, locks and bolts from the inhabitants, although until the German troops came, your honest Belgian will tell you, he never had much use for such hardware.

Belgium is a rather Lilliputian country, from the American viewpoint, for it comprises only 11,373 square miles of territory, and is only slightly larger than our own small state of Vermont, but with 22 times Vermont's population. The mighty American state of Texas, the largest in the Union, would hold more than 23 countries the size of Belgium, but tiny Belgium's population is double that of Texas, the kingdom supporting more than 600 souls to the square mile on the average. The population figures are important in a relative economic sense, because there is a fraction more than one person to each of the 7,278,000 acres of territory, and of this acreage half a million is water and waste land, one-eighth of the total is meadow and pasture and one-sixth wooded country. About 130,000 acres, I learned, are occupied by farmers engaged in intensive truck gardening, a highly important source of revenue that is practically as important as it is in the neighboring country of Holland. As a result delicious fruits and vegetables are plentiful and cheap in the cities, and they are also exported. Roughly, about a half of the Belgian population is supported by the land, more than a million being directly



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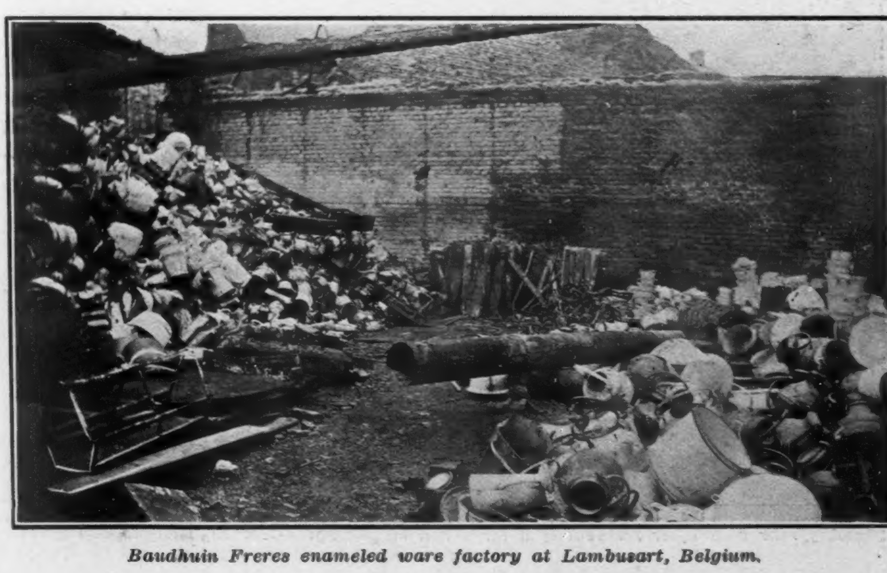
Typical scene in Belgium after destruction by the Germans.

© Timmermans, Brussels.

Panorama taken from the tower of the town-hall, Brussels. The church of St. Gudule and the Colonne du Congres dominate.



Baudhuin Freres enameled ware factory at Lambusart, Belgium.

Showing front view after removal of a large rail mill—Ougree-Marihaye works at Ougree, Belgium.

employed in its cultivation. In the last two seasons of 1920 and 1921 there has been a great agricultural boom in the country and good markets for the produce.

The employed portion of the remainder of Belgium's population is engaged largely in commerce and the metallurgical, mining and textile industries. Of course the relation of agriculture to commerce is not the same throughout Belgium. In Liége only about ten per cent. are agricultural workers, as this is the great industrial centre. In nearby Luxemburg, which duchy may be traversed easily in a day's motoring, 40 per cent. of the population is agricultural. Industrially, Luxemburg may be considered as a part of Belgium, and many large mercantile houses do classify it as such for business convenience.

The agricultural productivity of Belgium, already touched upon, furnishes the food that provides the man-power behind industrial power, and in so well ordered a small state it is of great consequence, though not so directly productive of wealth as the mines, and the industries dependent upon them. Mining is the mainstay of the country. In addition to an extensive coal field, which ranks next in importance to those of England and Wales, the mines of Belgium produce iron, lead, zinc, copper, manganese and calamine, all of which raw materials, long the envy of the Germans, are converted into manufactures.

In the exploitation of this mineral wealth both the new and the more venerable types of air compressors of American, English and German makes are employed, along with rock drills, hoists, drill sharpeners and compressed air locomotives. There have been considerable purchases from American and English pneumatic machinery houses since the termination of the war. The Belgian machinery market, considering what the rates of exchange have been, the state of buying power and other pertinent factors, has been surprisingly active for the last two years, but it will sharply improve when the internal financial problems of Belgium have been more definitely solved, according to the trade authorities at Brussels.

The work of driving shafts is now going on in the ten new concessions in the Campine coal district. Some of them already show a considerable output, although in most cases the shafts have to be driven 1800 feet or more before extraction is begun. The Winterslag mine, the most successful of the Campine concessions to date, is now turning out about a thousand tons of coal per day.

Before the war the country was employing 35,000 men in 1,550 quarries having an output valued at around 70,000,000 gold francs a year. The Belgian quarrymen, like those of neighboring France, are learning that the most economical and effective quarrying machinery is that for which compressed air is the power medium and there is a constantly growing market for this class of equipment. Belgium has usually produced about 250,000 metric tons of iron ore a year, but it has also been obliged to ship in additional ore from the nearby Luxemburg deposits in order to keep up with the requirements in pig iron.

The kingdom had 55 blast furnaces and a hundred puddling furnaces before the war. In visiting the furnace region the writer ascertained that more than half of them had been blown in, but that others could not be operated because of the dearth of coke. The average of about 55,000 to 60,000 tons of fuel a month received from Germany, however, has helped to some extent in offsetting the diminished coal receipts from the home mines, and the situation has gradually bettered. Among the newer furnaces there are some excellent examples of modern air blast installations, certain of them of English and Belgian, and others of American design.

Lead production totals 50 million gold francs a year in value, but of course zinc is much more important, the tonnage exceeding 200,000 a year usually, and being valued at 135 million gold francs. Pre-war zinc mining profits in Belgium averaged 75 per cent., through the workings of the international zinc syndicate.

Before the war Belgium was the third zinc smelting country in the world, producing about 200,000 tons of unmanufactured zinc per year, of which about 75 per cent. was exported. During the ten years prior to the war, Belgium indeed produced over 20 per cent. of the world's supply, in spite of the fact that practically all the ore was imported. It is the great difficulty of obtaining ore from Australia and other former sources of supply that now chiefly retards the resumption of this important industry. There have lately been some purchases in the United States.

The silver from lead deposits runs to 32,-

Showing rear view after removal of a large rail mill—Ougree-Marihaye works at Ougree, Belgium.

000,000 francs a year. The entire mining industry is encouraged and fathered by the Government's Department of Industry and Labor, comparable to the United States Department of Commerce. Expert advice is furnished to the mine owners, who are protected against slovenly methods and outside competitive influences. Practically all industry in Belgium is accorded this kind of paternal assistance from the government, which was so good as to furnish some of the current data and illustrations for this article.

The endeavors of the government in encouraging industry are well supplemented by individual initiative and by various public organizations. One of these is the alert American-Belgian Chamber of Commerce, the membership of which includes leading Belgian and North and South American houses. On the reading tables of the library of the Chamber, which is located at No. 86, Rue de la Montagne, Brussels, I noted well-thumbed back issues of COMPRESSED AIR MAGAZINE, and no fewer than 35 other technical and trade development journals published in the United States.

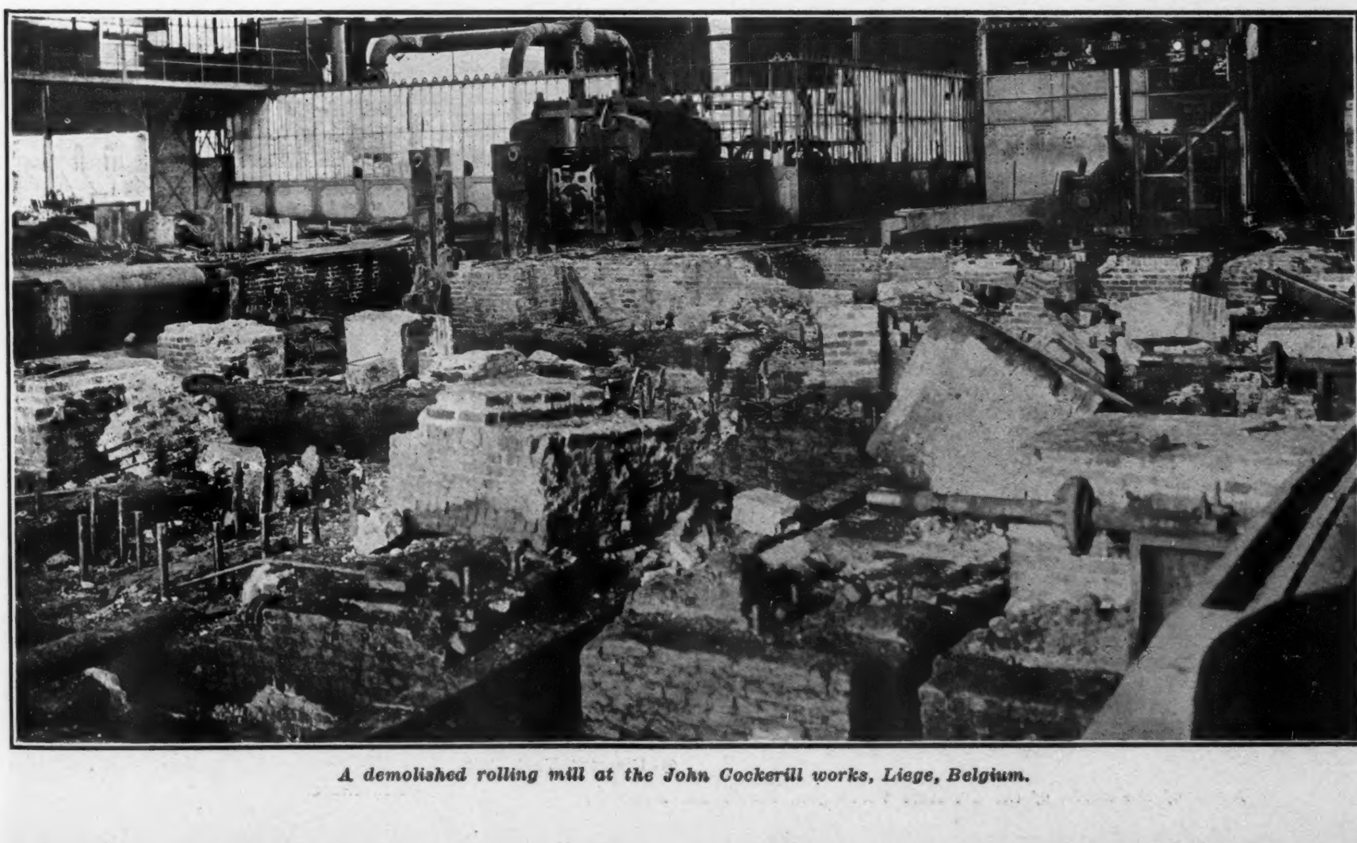
All that is left of a blooming mill at the Ougree-Marihaye works at Ougree, Belgium.

The courteous secretaries and assistants of the Chamber, and M. Marcel Goffin, a prominent engineer and business man of Brussels, the United States Trade Commissioners having headquarters at Brussels, and individual industrial executives in Liége, provided a wealth of information to indicate the present-day status of the country and the measure of its recovery.

The conditions of Belgian exchange have worked hardships against the country as regards purchases in America, but on the other hand, with an increasing output of manufactured goods, it is of advantage to Belgium to export as much as possible in an effort to offset its adverse trade balance. The American-Belgian Chamber of Commerce, which carefully watches the situation, is doing earnest and splendid work in facilitating actual buying and selling between the two countries. In one month of which note was made it received 232 letters from America, sent out 184 in addition to general trade notices, and successfully handled 36 trade inquiries resulting in business. A specimen record such as that has fully justified the moderate expense of maintenance and given ground for the satisfaction of the membership.

Admitting the fulfillment of Germany's indemnity payments, several of which have already been made to the Allies, the outlook for Belgium is encouraging as far as her public treasury is concerned, and industrial production and ensuing sales have justified a degree of optimism for the future. The tourniquet has long since been applied to "Bleeding Belgium," although not too tightly, it may be suspected. The country still requires generous credits from America and its European neighbors in order that its exchange and monetary systems may be rectified for the benefit of both foreign and domestic trade.

After the war's huge wastage, all of Europe including the Central Powers, is in a state of interdependent solidarity, and no matter what the hatreds and prejudices engendered by the



A demolished rolling mill at the John Cockerill works, Liege, Belgium.

war, these countries, taken as a group, can only find their restoration in united action. There will be continuing evil times unless there is uniformity in the ameliorative measures taken by the various members of the group, and the Belgians are apparently more outspokenly aware of this fact than are the French. The quicker the press and the national spokesmen educate their peoples to this mental attitude, the quicker will normal conditions reappear not only in Europe, but in America. This is the unanimous opinion of the best-informed bankers in Belgium.

In the absence of sufficient Belgian exports, an immediate practical remedy that was set forth to hasten the return of prosperity, was the question of long-term credits. According to a Belgian business view, such credits might only be obtained if a general European organization was set on foot to arrange that customs and other revenues be pledged against such credits from the United States and from neutral countries. The administration of President Harding at Washington has already declared itself favorably, in principle, on the subject of promoting credits for needy European countries, which subject has had the attention of the Treasury and Commerce Departments, so the future holds some hope both for American manufacturers and European buyers of their goods. The best opinion seems to be, however, that the improvement in the situation will be only gradual until the spring of 1922, when a pronounced upward swing of the international business barometer is confidently expected.

In manufactures, Belgium is deservedly known as "the laboratory and workshop of Europe." Its artisans work in metal, leather, lace, silk, cotton and wool. Flax is a valuable Belgian product. Last year's crop was good, but the linen industry is still faced by flax shortage. The great seats of linen manufacture—the oldest in Belgium—have always been in Flanders, where 350,000 workers were employed. Linen manufactures are still highly important but have not yet regained their prewar importance. The old time lace industry has dwindled to some extent, but still employed 150,000 people up to war days and a capital of about one hundred million francs.

Another view of a demolished rolling mill at John Cockerill Works, Liege, Belgium.

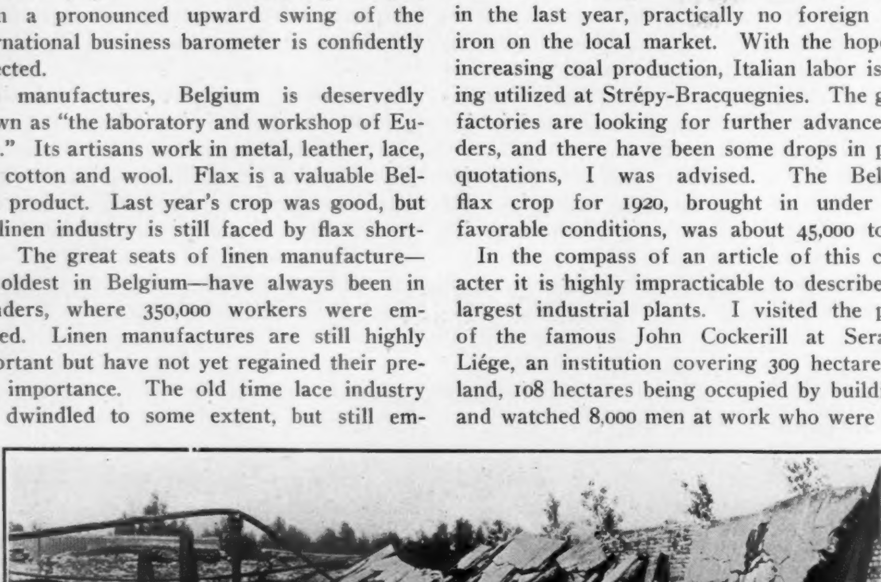
In the metallurgical industries it would be possible to increase the output radically if the demand were augmented, but there has been, in the last year, practically no foreign pig-iron on the local market. With the hope of increasing coal production, Italian labor is being utilized at Strépy-Bracquegnies. The glass factories are looking for further advance orders, and there have been some drops in price quotations, I was advised. The Belgian flax crop for 1920, brought in under unfavorable conditions, was about 45,000 tons.

In the compass of an article of this character it is highly impracticable to describe the largest industrial plants. I visited the plant of the famous John Cockerill at Seraing, Liége, an institution covering 309 hectares of land, 108 hectares being occupied by buildings, and watched 8,000 men at work who were utilizing many forms of Ingersoll-Rand air equipment.

It is a plant of which any country in the world might well be proud. Like other great concerns in Belgium, it suffered from war's ravages, but it is now well on its way back to normal conditions. Before the war the works employed 11,000 men; that number of workmen will soon be employed again, judging by progress made. The company owns its mines and furnaces and carries on its entire process from raw material to finished product a la Henry Ford.

An engine built by the Cockerill Society, as was lately published in these columns, is said to be the most powerful gas engine in the world. It was in process of erection in August, 1914. The Germans after the capture of Liége allowed it to be put into operation and when they were assured of its success, took it from its owners and sent it into Germany, to Duisburg, where it was running at the time of the Armistice. It was then sent back to Liége, where it was installed for the second time, with the addition of some improvements. It develops 8,000 horsepower. The cylinders, four in number, are 1.3 m. (51 in.) in diameter, 1.5 m (59 in.) stroke, 94 r. p. m. The heat of the gases coming from the engine is used to generate steam for a turbine.

I found a strong tie of social and business friendship between Belgians and Americans, as might be expected for reasons no modest American need mention, and it is not an affection of amity and concord. Belgians were greatly pleased by the reception accorded in America to the King and the Queen of the Belgians, and home folks from "the States" will always be welcome guests in that part of Europe. And as long as Herbert Hoover is Secretary, the Department of Commerce will have no difficulty in gathering the trade statistics there.



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Ruins of the works of the Ste Ame Vertongen, Termonde, Belgium.

Experiments on the Effects of Extremely High Pressures

Interesting Results Obtained in Dealing With Pressures as High as 20,000 Atmospheres Throw Doubt on Some Commonly Accepted Beliefs

By P. W. BRIDGMAN

THE FIELD OF high pressures is one in which little work has been done, but is coming to be recognized as one of fundamental importance. For instance, the high pressures as well as the high temperatures in the stars are probably both vital in the genesis of the chemical elements.

It has been my good fortune to have specialized in this field of experiment, and I am glad to take this opportunity offered me by the COMPRESSED AIR MAGAZINE to give a summary of some of the more important results obtained to date, particularly in view of the fact that several popular accounts have recently been making the rounds which are not accurate in all particulars.

In the first place a word as to the magnitude of the pressures with which we are to deal. In my experiments I have succeeded in accurately measuring pressures as high as 20,000 atmospheres, or about 300,000 pounds to the square inch. This is 200 times as high as the pressure at which compressed gas is usually shipped in steel bottles, and is ten times as high as the pressure of the exploding powder in a large gun. Compared with the pressures reached in nature, it is twenty times as high as the pressure in the deepest part of the ocean, which has been popularly considered to be an almost inconceivable pressure.

The wildest and most contradictory stories are in circulation as to the effects produced by the tremendous pressures at the bottom of the ocean. On the one hand we are told that water is forced bodily through pores in steel vessels, and on the other hand that water is so powerfully compressed that it becomes even denser than iron, so that all the iron ships that have foundered float around forever at the level where the density of water has become equal to that of iron. Both of these statements are of course utterly absurd; iron ships do sink to the bottom, and if an iron bottle leaks it is because the joints were not tight. However, although we may be scornful of the pressure which nature gives in the oceans of this globe, we certainly have to bow down when we consider the billions of atmospheres in some of the stars.

The maximum pressures which had been employed in previous experimenting of a scientific kind were about 3,000 atmospheres. That I was able to extend this range by six or seven fold was due primarily to the design of a particular packing which is absolutely without leak as long as the steel containing vessel is itself strong enough to withstand it. In brief, the design is such that the pressure in some soft material such as rubber or lead or soft steel is automatically maintained at a fixed percentage higher than the pressure in the liquid which is trying to leak past. The liquid itself, therefore, cannot leak by the soft packing, and the packing problem reduces itself to the mechanically simple one of preventing the packing material itself from leaking.

It is easy to see that an extension of the previous pressure range of six or seven fold involved a large amount of preliminary surveying of the ground, since many of the properties of matter are altered. I found almost at once that the engineering theories of the strength of vessels are of no value at high pressures. A cylinder will stand much more pressure than it is ordinarily credited with, and will also stretch a great deal more than the ordinary tensile tests would suggest, and when it does break the curious thing is that the crack starts on the outside, where the stretch and stress are least, and travels toward the inside, where they are greatest.

Figs. 1, 2 and 3 show cylinders which were broken in the preliminary work. Fig. 1 is a cylinder of tool steel that ruptured after supporting 40,000 atmospheres. The crack started on the outside at the point marked A, and the inside stretched about 125 per cent., against 25 per cent. in an ordinary tensile test. Figs. 2 and 3 show a mild steel cylinder, which stretched about 150 per cent. on the inside, and started to break on the outside. The steel which I finally adopted was a chrome vanadium steel, heat treated to give the maximum strength. In order to allow the heat treating to extend throughout the mass of the steel, the dimensions of the apparatus must be kept small.

A view of the apparatus with which many of the experiments were performed is shown in Fig. 4. Pressure is produced in the upper cylinder by a small piston driven by a hydraulic press operated by the hand pump. Pressure is transmitted through a connecting pipe, which has to be drilled out of the solid bar, to a lower cylinder containing the particular object under experiment. The dimensions are small; the upper cylinder is only 4½ in. outside diameter, and the hole one-half inch.

One of the most serious of the early problems was the design of a suitable gage. Of course none of the ordinary gages are of the slightest use. The simplest possible scheme, a suitable modification of the familiar dead weight gage, was finally made to work. With a gage once in hand, secondary standards of pressure could be constructed. One of the most convenient of these is the change produced by pressure in the electrical resistance of a metal. The alloy called manganin is most suitable, and I have used it in most of my work.

Other necessary preliminary experiments consisted in finding how much truth there is in the superstition that metals become permeable to liquids under very high pressures. I soon found that there is no truth in these ideas; it is not possible to force an ordinary liquid into the pores of any metal that I know by the highest pressure that I can reach. Previous results were due to flaws in the metal. However, I have found quite recently, and these results are here published for the first time, that the case is different with some gases. Hydrogen compressed to a pressure of 10,000 atmospheres will eat its way through a massive steel container, and blow out, and if the experiment is repeated often enough will eventually make a crack that can be seen with the naked eye.

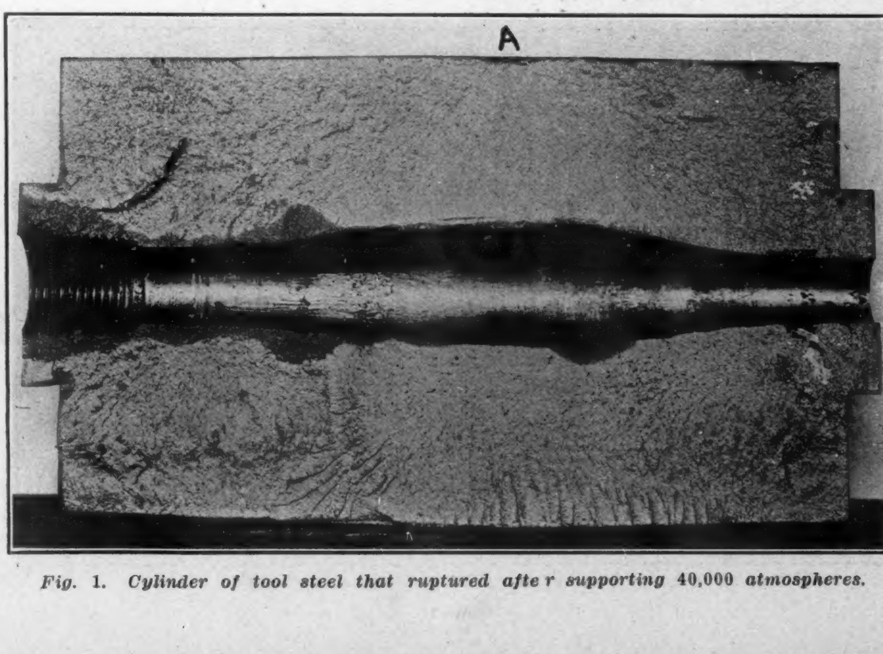


Fig. 1. Cylinder of tool steel that ruptured after supporting 40,000 atmospheres.

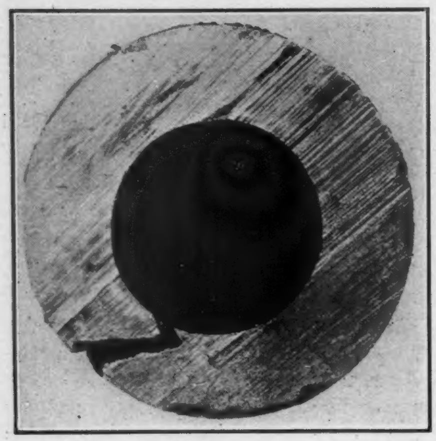


Fig. 2. A mild steel cylinder that started to break on the outside after an internal elongation of about 150 per cent.

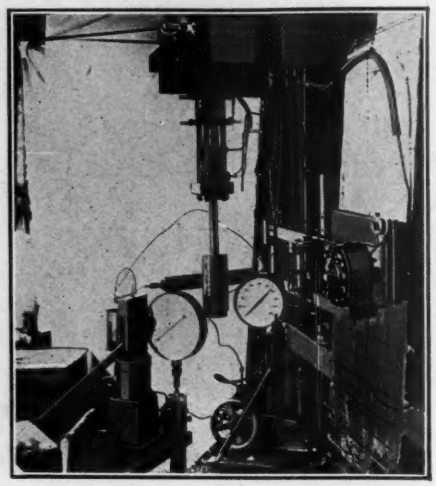


Fig. 4. Apparatus with which many of the experiments were performed.

Compressed air also apparently behaves in the same way, although in this case the action is slower, and a pressure of even 15,000 atmospheres may be maintained in a steel container for a short time. It is fortunate, therefore, that industry is satisfied with its air compressed to 100 instead of 10,000 atmospheres. Mercury behaves much like hydrogen; it can be forced through massive steel walls by about 6,000 atmospheres. The action of hydrogen is doubtless due to the extreme smallness of the atom, the action of mercury is probably somewhat like it, assisted by an amalgamation with the iron, and the effect with air is probably partly an oxidation.

One of the first subjects calling for investigation at these high pressures was the compressibility of liquids and solids. Liquids are usually thought of as nearly incompressible, but this is only because of the small pressure with which we are ordinarily familiar. As a matter of fact, liquids are comparatively highly compressible. Water may be compressed to twenty per cent less than its normal volume by 12,000 atmospheres, and alcohol may be compressed by twenty-seven per cent of its initial volume.

The compressibility of metals is much less than that of liquids, but still is very appreciable under these high pressures. Under 12,000 atmospheres the decrease of volume of a metal like zinc is more than three times as great as it would be if cooled to the absolute zero of temperature. The essential difference between a solid and a liquid is that most of the compressibility of the liquid is owing to taking up the slack between the molecules, whereas the compressibility of a solid is owing to the compressibility of the atoms themselves.

The compression of a liquid cannot be carried indefinitely, because when the pressure is pushed high enough, it will be forced to freeze, no matter how hot it is. This phenomenon was a source of annoyance in my early work. I found that when I used ordinary machine oil to transmit pressure not more than 4,000 atmospheres could be reached at room temperature. This was due to the oil freezing solid under pressure. The remedy is to use a lighter oil such as kerosene, or even gasoline, which will not freeze until at considerably higher pressure. Before these experiments were made it was not known whether a liquid could be forced to freeze by a high enough pressure or not.

There were various theories; one was that there is a critical point between liquid and solid just as there is between liquid and vapor, and another that there is a temperature beyond which no amount of pressure can force the liquid to freeze. However, none of the theories stood the test of actual experiment. One can see how important establishing this fact is for the geologist, who wants to know whether the interior of the earth is solid or liquid.

That a liquid can be forced to freeze by enough pressure is true even for water. This is not what one would expect, for when pressure is first applied to water the effect is to make it freeze at a lower instead of a higher temperature. Everyone knows that the reason a skate slips on ice is because the solid ice is melted to liquid water by the pressure of the runners. But if the pressure on ice is raised to about 2,000 atmospheres, something suddenly happens; the slack between the molecules is squeezed out, the ice collapses eighteen per cent. in volume and assumes a new appearance with new physical properties.

For instance, this new kind of ice will sink instead of float in water. Now if this new kind of ice is squeezed some more, presently some more slack is squeezed out and still another kind of ice appears. This process may be again repeated at still higher pressures. The kind of ice now formed has apparently lost all the slack that it wants to, and does not change into another kind. Water at 180 degrees Fahrenheit may be forced to *freeze* to this kind of ice by the application of about 20,000 atmospheres. Do not be misled, however, and expect some day to find some of this ice lying around in the streets, because the instant pressure is released it melts back into ordinary liquid water.

There are many other substances beside water that have a lot of slack between the atoms or molecules and that may be forced to assume other forms by extremely high pressures. For instance, ordinary camphor can assume at least six different forms; that is, the molecules can build themselves together into a crystal in six different ways under the right conditions of pressure and temperature. One of the most interesting of these transformations is that of phosphorus, which under 12,000 atmospheres and 200° C assumes a black form like graphite in appearance, which has lost its combustibility, has become a conductor of electricity, and is 50 per cent. more dense than the familiar yellow phosphorus. This transformation, unlike that of ice, is permanent, and the new modification does not go back to the original when pressure is removed.

Another very striking change produced by high pressures is in the viscosity of liquids or soft solids. Ordinary lubricating oil becomes 25 or 30 times "stiffer" under a pressure of only a thousand atmospheres or so. Other substances may become thousands of times stiffer under the same pressure. Under 12,000 atmospheres ordinary paraffine wax becomes so stiff that it can deform steel, and soft rubber becomes harder than mild steel, so that a steel disc may be squeezed in ridges into the cracks of a soft rubber washer, as into a die. Knowledge of such phenomena as these is of great importance to the geologist in showing the condition of the interior of the earth.

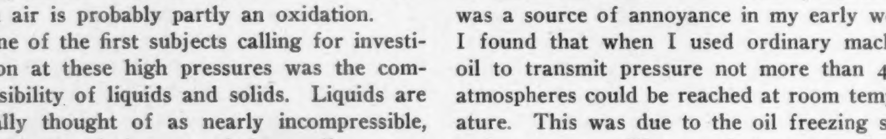


Fig. 3. Another view of the mild steel cylinder shown in Fig. 2.

In addition to all these effects, there are many others of equal importance for theoretical physics, but perhaps less spectacular. For instance, the electrical properties of metals can be profoundly altered by high pressures; it is possible to make a metal like sodium or potassium conduct electricity five or ten times as well as under ordinary circumstances.

PROGRESS IN CIVIL AVIATION

MUCH INFORMATION, definite and reliable, of interest to those who are considering the future of American aviation, is contained in the recent half-yearly report presented by the British Air Ministry.

During this period of six months it showed a total of 689,600 machine miles were flown by British civil aviators, a large increase over the mileage of the preceding half-year. The number of passengers carried has also increased, the figure for the period named being 32,345. The number of departures and arrivals to and from England and the Continent has increased from 734 to 2445.

This large development in civil aviation has naturally brought with it many improvements in service and facilities. Landing fields have increased in number and have been improved in quality. Regulations regarding pilots have been revised, and extensive research in regard to power plants has been carried on.

Interesting investigations have also been carried out to minimize the effects of mist and fog by mechanical dispersal, to secure the illumination of landing grounds, and to produce mechanical apparatus to cause machines to flatten out automatically before touching the ground. Methods have also been investigated for obtaining instruments to indicate accurately to the pilot his position in relation to the airdrome, and his height above the ground.

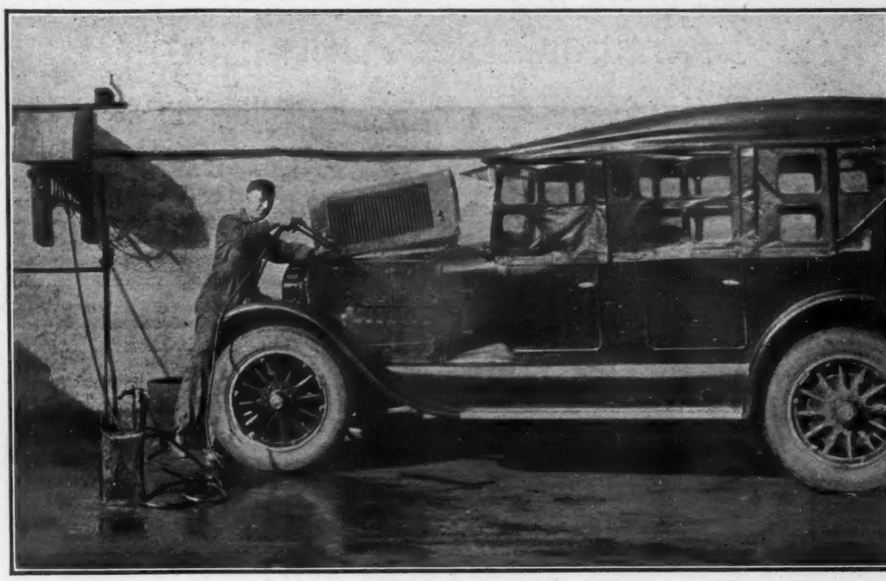
The Department of Research has been paying special attention to the development of new types of power plant. If these experiments are successful it will be possible to use a fuel of a higher flash point, thus increasing both safety and cheapness.

Several new designs of aircraft with facilities for making adjustments to the engines during the flight are being made, and a satisfactory engine starter for use on the ground is now available.

SERVICE STATION EXTENDS COMPRESSED AIR USES

BESIDES using compressed air for the ordinary purpose of tire inflation the automobile service station of the Walter M. Murphy Company, San Francisco, has found various other services for this power medium.

The air equipment in this garage consists of a small electric driven air compressor installed on the roof of the building with an air tank located nearby. The air is cooled by passing through a coil attached to the concrete wall and is piped throughout the building. A second supply tank is located in the basement to assist in maintaining a uniform pressure.



Spraying and cleaning parts of engine with compressed air.

The accompanying illustration shows the spraying and cleaning of parts with compressed air and distillate. The spraying device consists of a 5-gal. can with a 10-ft. rubber hose which leads from the can to the spray nozzle. The can is filled with distillate and by means of compressed air is sprayed against the parts to be cleaned. A sump is provided which collects the grease from the parts. The 10-ft. hose to which the nozzle is attached is wound up on a reel, a spring and chain always keeping the hose wound up when not in use.

In the sheet metal department air is used in testing out radiators. A safety valve set at 20 lbs. is inserted in the line to eliminate the possibility of bursting the radiator tubes due to high pressure. In this department compressed air also serves in operating a combined air and gas torch. Air connections are provided at numerous points so that the air may be conveniently used.

A PUFF OF AIR MADE IT ALL RIGHT

N. T. T. in "Machinery."

A YOUNG FELLOW applied for a job as a die-setter in a power-press shop of considerable size, and was engaged on the strength of the glowing capabilities he claimed for himself. The first task given him was to set up and try out a die for stamping a simple circular blank of very light metal, and he was given the choice of two presses for the purpose. Both presses were small and of equal capacity, but one was of the straight-sided type, while the other was an inclinable press. He chose the latter for the work. The boss kept his eye on the young die-setter because, from a previous inspection of the construction of the die, he knew that the stamping would not lift out and slide away from the press of its own accord, even though the machine was inclined at a generous angle.

When the die had been set up and was tried out, the result was not as the die-setter expected, but as the boss had anticipated: the work would not slide off the die. The young fellow seemed puzzled for a minute; then his worried look changed to one of hope and understanding. He left the press for a few minutes and returned with a hand bellows. This he gave to his helper and stationed the latter in a sitting position on the floor and under the press. The helper was then instructed to place the nozzle in a vent in the bottom of the die and to squeeze hard immediately after each tripping of the machine. The helper followed the instructions faithfully and the stampings kept flowing out of the die and rolling from the press after each operation. Thus, the young genius not only made good on his new job, but also instituted the first compressed air device for the removal of small stampings from a press, even though it was operated by a "human knock-out."

METEOROLOGICAL ACOUSTICS

Mr. J. W. Humphreys in the *Journal of the Franklin Institute*, writing under the above title, says that thunder is heard more than fifteen miles. This is much less than the distance to which guns are sometimes heard. The circumstances in the two cases, however, are radically different. The sound energy from a gun is relatively concentrated, since it all starts from a single point and spreads out in a hemispherical shell, whereas, that of thunder starts, not from a single point, but from a crooked line often miles long. Furthermore, guns often are fired when the surface air in which the firing occurs is very still and otherwise in the best state for long transmissions of sound. Thunder, on the other hand, seldom occurs except when the winds are turbulent and the general conditions very adverse to sound propagation. Finally, the density of the air is greater at the gun than along the lightning path, and hence its sound energy per unit volume, other things being equal, is also correspondingly greater.

The Charles Stone Co., operating a large limestone quarry at White Hall, Ill., fired a record shot on June 8th. Drilling to a depth of 100 ft, they put 7½ tons of dynamite in the holes and set it off, loosening 70,000 tons of stone with one blast.

A Transportable Aluminum Air Compressor Outfit

One Cylinder Gas Engine Driven, for Rock Drilling at High Altitudes, and Hauled by One Man, Developed by a Captain of Army Engineers

GREAT INTEREST has been manifested in the transportable air compressor outfit of aluminum and other light metals, designed for rock-drilling at high altitudes and in places which are inaccessible for heavier equipment, that was developed for the use of the Austrian Army in the course of the war. The present interest centers around a question as to whether such a light-metal apparatus, which can be hauled on a two-wheeled car body by one man, is susceptible of use in everyday mining, road-building, or small tunneling operations at great heights in mountainous country. Judging by the descriptions of the machine and its accoutrements, which with the accompanying photographic illustrations were obtained by the writer at Vienna, this question of its adaptability for certain non-military usage may be answered in the affirmative.

Capt. Desiderius Ernyei, formerly of the Austrian Army Engineers, and a lecturer and writer on engineering subjects at Vienna, assisted largely in evolving this small, but fairly powerful machine, which was no mean task. In the final stages of the great rock-drilling contests between the engineer corps of the Italian and Austrian armies, which campaign was described in detail in the issue of COMPRESSED AIR MAGAZINE for February, 1921, that was later reproduced for popular consumption in *Current Opinion* for May, it was learned through experience that comparatively heavy and cumbrous compressor outfits, even though portable, were very difficult to use at great heights.

At many places in the Alps where drilling operations were desired there were not even mountain trails, say nothing of roads, and the hazards of transport in these lofty places may easily be imagined. The Austrian engineers therefore brought out their very light transportable compressor outfit, of which the following is the first description to appear in any publication.

It had a minimum of weight and could be dismantled into a few parts by unskilled hands and just as easily reassembled. In smooth, level going it could be hauled by one man with little difficulty, but draft animals were used to pull it up the sides of the eternal granite.

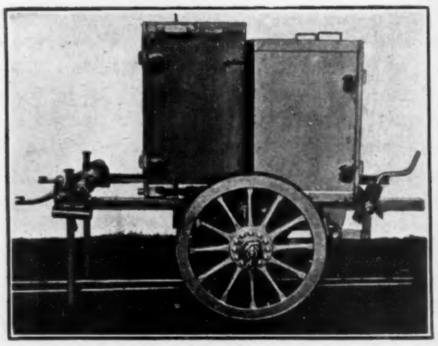
The outfit consisted of a one-cylinder gasoline engine, directly coupled with a one-stage, single-acting air compressor. This compressor, having a weight unpacked of about 140 pounds, and packed, of 160 pounds, could be carried by a small mule or cavalry horse in one package. The fly-wheel alone had to removed, this piece forming a special part load, but its weight also was small, amounting only to 90 pounds. Other pack animals conveyed the necessary accessories.

The diameter of the compressor cylinder was 150 mm. (about six inches) and the stroke was 130 mm., or about five and one-eighth inches. The actually delivered free air per minute was 1,000 liters (about 35 cubic feet) at seven atmospheres per square inch (100 lbs.) end pressure. The revolutions of the direct-coupled aggregate were 650 per minute.

The two-cycle gasoline motor cylinder had a diameter of 130 mm. (five and one-eighth inches) and a stroke of the same dimension, and an effective capacity of about seven and one-half horse power.

This small, light and compact compressed air power plant was so constructed and designed as to be able to drive a hammer drill of smallest type in the rarefied atmosphere of the upper Alps. The illustrations indicate the general construction of the unit and its ease of conveyance.

It is interesting to note that the cooling of the compressor and the motor was accomplished by a radiator cooler in such fashion that the water took its course first through the compressor, its temperature rising there by only a few degrees, and then through the motor. Two tin boxes filled with sand and broken stone served as foundation for each section, the emptied boxes being used in transport for packing the material.

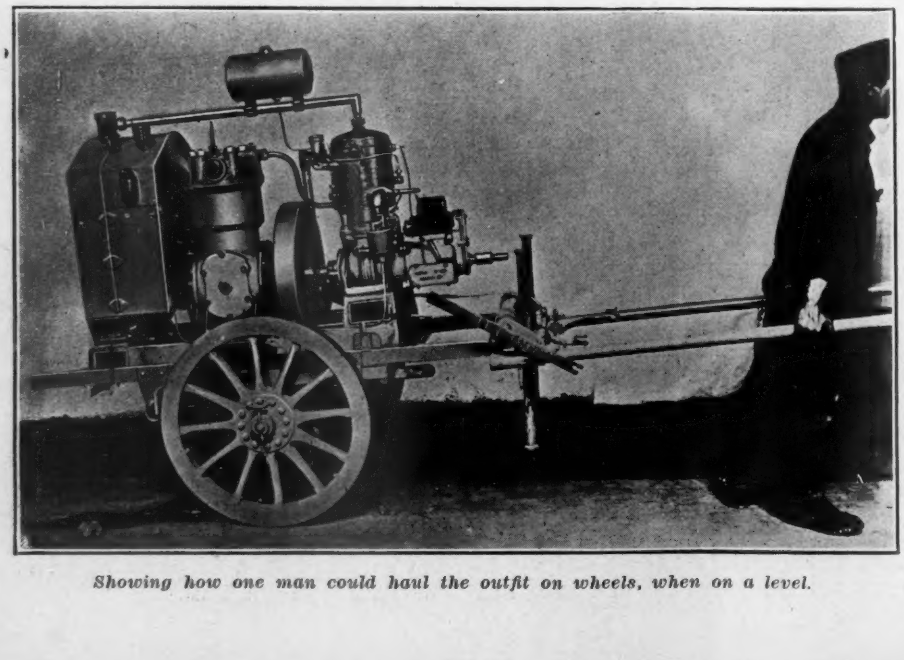


The aluminum compressor and motor packed in van as for transport.

The entire plant, including space for operation, when set up occupied a ground space only six by nine feet. Instead of piping, each set employed air hose, which was also packed in cases. The complete unit, it may be stated, including all of the accessories, blacksmith tools and about 600 feet of air hose, was carried by ten animals. Two of such compressor outfits, in military usage, formed a squad, and sixteen soldiers were assigned to each squad in order to handle the two outfits, animals and operate the units when working, including the drills. In other words eight men were told off for all purposes for each compressor outfit.

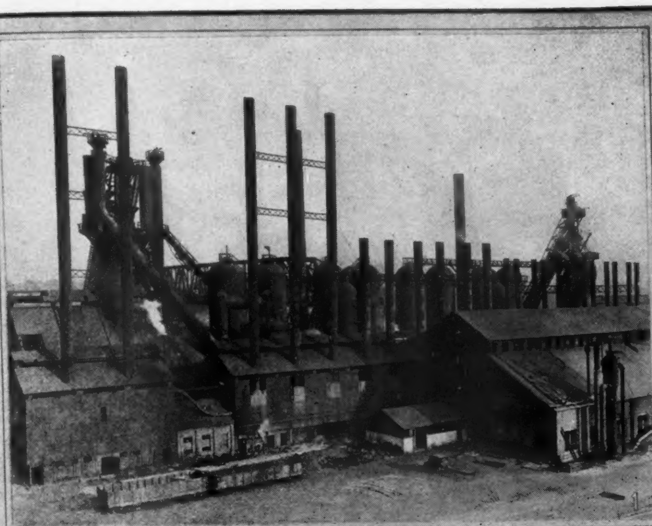
Captain Ernyei said that in the beginning the Austrians experienced great difficulties in turning out good pistons of aluminum, but at last they succeeded in ascertaining just the right metal alloy for the purpose. The exhaust canal of the gasoline motor was made removable to provide for an interchangeable spare part in case of undue wear or enlargement of the exhaust opening.

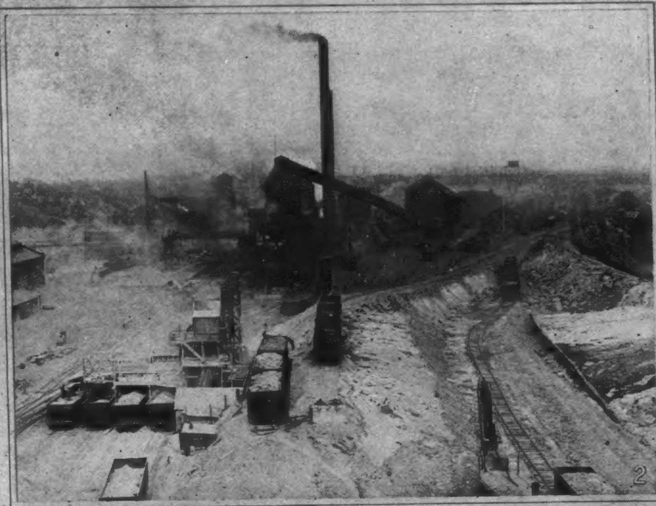
The transportable aluminum compressor power plant unit was not introduced into actual practice by the engineers until a short time before the cessation of hostilities, it was learned, but it was declared to have operated with entire satisfaction. F. J. T.

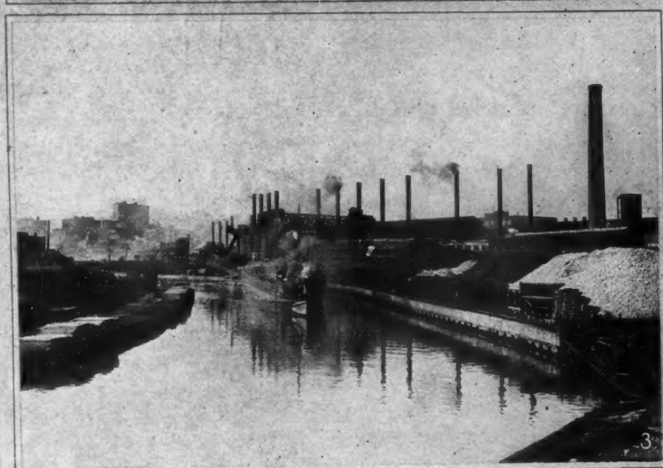


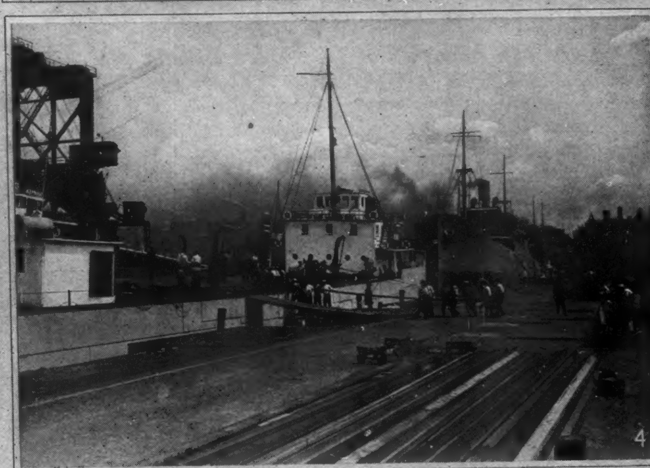
Showing how one man could haul the outfit on wheels, when on a level.

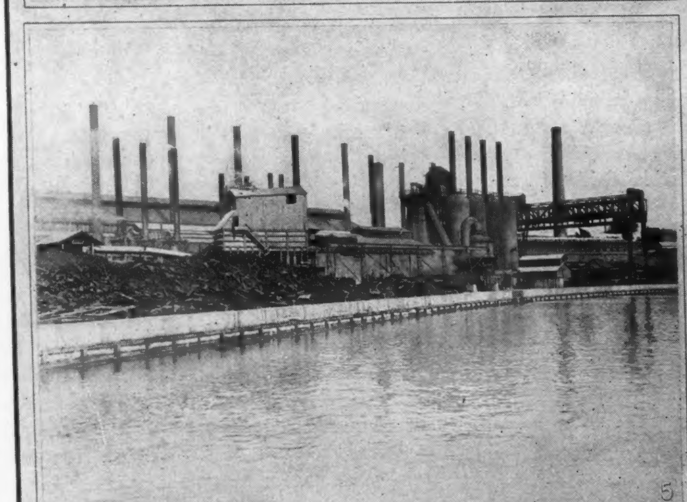
Cleveland, One of America's Great Manufacturing Centers











Although not so widely known as Pittsburgh, the City of Cleveland is one of the great iron and steel centres of the world, and as such it is one of the most important of compressed air consumption districts. The city is famous for its great machine tool factories and in general for its import- ant engineering works. It is not only a highly important Great Lakes terminal port, but is greatly favored, through its natural location, as a rail- way centre. The new photographs we show above will prove illuminating not only to our English and European readers but to many Americans who have not visited this great and rapidly growing industrial metropolis in recent years View No. 1 shows the plant of the Cleveland Steel Mills. No. 2—A modern coke plant owned by the big McKinney steel concern. At the left is the limestone grinding plant. No. 3—A striking view of the Up- son Steel Mills on the Cayohoga River, with an ore steamer in the central foreground and a part of the city's skyline in the background. No. 4— Here are seen Great Lakes freshwater ships loading steel rail cargoes for Western Canada. The ore that came down the lakes goes back to Duluth as a finished steel product. No. 5—Another view of the Upson Steel Mills. No. 6—View of one end of the Public Square of Cleveland in the heart of the business district where the steel companies have their headquarters.

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EDITORIALS

THE USE OF GUNITE IN MINES

IT IS NOT often that an engineering construction method springs into being almost full-fledged, but this appears to be the case with the method of applying cement-sand mixtures with compressed air, and in fact it is unique in that there appears to be no substitute to efficiently accomplish this particular purpose. Plastering by hand does not give the result, as the sand-cement mortar to efficiently bond with the material to which it is applied, whether iron, concrete, or rock, must be driven on by the high velocity imparted by compressed air.

The invention of a machine called the "Cement Gun" with which the sand-cement mixture is applied, made the development of the method possible. Earlier attempts of using water jets or compressed air with wet mixtures proved to be failures, but the mixing of dry material with water at the discharge nozzle of the gun made the method immediatley successful and this is the vital feature of the "gun." The first use was in applying stucco on buildings in 1909-1910 and the machine essentially in its present form made its debut at the exhibition of the National Association of Cement Users at New York in 1910. After that it was gradually tried out in many ways: in the coating of old buildings, both wood and brick; the relining of tunnels, and the repairing of reservoirs and piers.

In the meeting above mentioned, Mr. GEO. S. RICE, Chief Mining Engineer of the U. S. Bureau of Mines, in the discussion of a paper on the use of concrete in mines, commented upon the opportunity for using the cement gun for lining mine passageways to prevent their weathering. In 1914 a cement gun was used under his direction for lining the Experimental Mine of the Bureau of Mines, near Pittsburgh, Pa. and shown at the American Institute of Mining Engineers meeting in that city.

The success of the coating, resisting as it did the effects of violent explosions as well as preventing weathering, attracted the attention of mine operators and engineers and its use in mines generally spread for a great variety of purposes such as fire-proofing of timbers and ventilation stoppings, the coating of wood shaft linings and the like. At first its use was confined to coal mines but later the Anaconda copper mine found that it was of greatest value in erecting fire stoppings and sealing cracks in the strata to prevent access of air to the fires.

More recently to the surprise of mining men it was found, on trial in the famous deep Calumet and Hecla Copper Mine, that it would prevent weathering in the hard rock formation as well as in the softer coal formation elsewhere, and for this purpose its use gradually spread.

The growing scarcity of timber and increasing cost, which so affects all kinds of mines, makes it expedient to protect mine timbering. Decay of timbers in mines seems to proceed largely from the surface inward and the rate of decay is very high in the moisture laden atmospheres of mines. The keeping away of fungus which rapidly gathers in wet mine passages is found to protect the timbers from abnormal decay and a wide field of usefulness obtains for this compressed air method in mines perhaps even more important than in the numerous surface uses. Thus, it appears to occupy a unique field of its own. Now it has made its appearance abroad and is attracting the attention of mining engineers and operators in Great Britain and other countries.

CHEAPER POWER IN GERMANY TO PAY REPARATIONS

THE REORGANIZATION of German industy, of which there has been so much heard in recent months, is based on cheaper power, not on coal as a fuel commodity. This fact is not of common knowledge by any means in America, nor is its significance yet fully grasped by the people of the British Isles. For immediate needs, in the next year or two, Germany's representatives, in dealing with the Allies, have of course stressed the subject of coal, but for the future coal can be discounted as a really disturbing element in the economic rehabilitation of Germany provided the Versailles Treaty terms as affecting Upper Silesia are carried out.

In the course of a recent survey of the principal industrial districts of Germany, we learned of the comprehensive plans of manufacturers, of power consumers in general and of the coal mining interests for the distribution of greatly cheapened power. On a new and fundamental industrial base, and it is well for American manufacturers to observe its plan and future workings with care since it is likely to figure actively in world competitive markets, is to be reared an Industrial State ruled by a private economic governing body having the barest minimum of official governmental control.

American super-power zone advocates, it would appear, will recognize the purpose of the German scheme, by means of which the middleman is to be eliminated through economical distribution of electric force, and they have their programme worked down to the point of quietly forcing its substitution for the plan of socializing the coal mines as had been demanded by the more radical labor groups. The new power plan is backed by the three strongest mine owners, STINNES, VOEGLER and SILVERBERG, and by the united employer group of the so-called Economic Parliament. As the months pass HUGO STINNES appears to loom higher and stronger as the great coal baron and the industrial and financial colossus of post-war Germany, and where he puts his weight something gives way.

This programme, comprising a reordering of Germany's economic fabric, utilizes the idea of power, and provides for the division of the country, for administrative purposes, into economic districts, each with its own power sources. Hydro-electric power, and much attention has been given this subject, will of course be used where feasible, but in addition, power produced at the coal mines will be distributed wherever it may be serviceable, in electric form. In other words, coal will be shipped by wire and the intermediate coal dealers and railways will be thrown out of cost calculations.

The result will cheapen largely manufacturing and general production costs with benefits accruing not only to the workman but to the employer and the entire population. Directly and indirectly much of Germany's reparation payments to the Allies will be met in this way, when these plans fully mature. The indemnity payments agreed upon amount virtually to a capital seizure of 20 per cent of the nation's wealth, private and public, it has been estimated. The eventual savings under the new Industrial State and power scheme, not only directly, but in the stimulation of export business which it is estimated will result, may more than offset the interest on the capital wealth seizures.

Setting such a programme in motion has signified an admission by the German powers that be, and these are more industrial than they are governmental, that they could pay the shot, investigators have been given to

understand. All of the developments in recent months have borne out the significance of this hint, for Germany has practically adopted the new economic scheme based on power distribution, although without any blare of brass bands, and the first payments to the Allies have been made.

The ultimate cashing in of the gold drafts is to be in manufactured goods, and the difference between the lowered manufacturing costs of these goods and their market value charged the Allies will be represented largely by the profits attributable to the workings of the Economic Parliament. Part of these economies will be reflected eventually in indemnity payments, and the remainder will be mutual profits, held in Germany. It is a plan worked out by the "best minds" of Germany. Wall Street financiers are not unfamiliar with it, nor are the financiers of London and Paris without knowledge of this system. It may help to explain the possible future of Germany's drafts in gold marks.

It is of interest to observe that the new economic union expects to have its large number of power stations completed in 1923, under this programme, and those in the Rhineland and in Westphalia within the next year—provided the Socialist element is not able to tip over the programme, and at the present writing this seems improbable, for many of the Socialists themselves, possibly against what they regard as the immediate ideals of labor, have been won over to the plan as the only feasible one either economically or politically.

It is an enormous enterprise, even in the American sense of that word. Shares are to be owned by the national and provincial governments, by the mine owners and by municipalities and individual workers and executives. Control for the present will rest with the employer group, but labor is to have representation in the directorates, and will have an indirect participation in profits through savings investments in local banks.

The plan means the disappearance of independent power services, which have grown to great dimensions in the Rhineland district.

It will be of interest to watch the development of this system of industrial management with a sharper curiosity than it would have attracted even in the period of industrial development before 1914. Germany has come to thoroughly realize her situation and is proceeding with plans to meet the situation. The commercial fortunes of all Europe are so indissolubly intertwined, willy-nilly, with those of Germany, regardless of racial lines, hatreds and prejudices, that Germany's success with her new industrial power plan will have an international significance.

Popular conditions respecting food, it is well to note, have been reversed in one year's time between Germany and France. Last year good food was difficult to obtain in most parts of Germany at any reasonable price; this year that condition has shifted to France, although later harvests and fresh imports will better the French situation this autumn. And food puts the man power behind industrial power.

MESOPOTAMIA AND THE JINN OF COMPRESSED AIR

IT SEEMS certain that the land of Mesopotamia will be much in the eye of the world for the next half-century. The benevolent hand of mechanical science will be extended to that territory. The result should be beneficial to all mankind.

What a romance it will be! This oldest of lands is to be made into one of the most modern; its anticipated great resources are to be opened in bountiful measure for the production of material benefits. It has been said by a European philosopher that "comfort is not culture." That is true. We should add, however, that comfort makes the growth of culture more rapid and easy, bringing it to the greater number, aiding the opportunity to come within grasping distance. Mesopotamia probably is destined to play an important role in such a development.

Mesopotamia, reputed the oldest of lands, is named in *Genesis* as the first cradle of the human race. It has known civilization well, for there resided the Assyrians and there lived the Babylonians. Their ancient palaces were built of wonderful bricks embedded in asphalt. It had its growth, its exaltation of power, its decay and fall. Mesopotamia was known as the most fruitful and delightful garden of the world of those ancient days. Its earth gave forth grains and fruits and flowers and when the soil became exhausted, engineers were summoned, and there resulted stupendous works for intensifying agriculture by irrigation, and these engineering feats held off famine and made the country rich.

Mesopotamia has lain fallow throughout more ages of man than one would think possible who knows the ceaseless quest of engineers and scientists for new sources of supplies. We are about to see it restored to its old-time glory, but a magnified glory. And compressed air and compressed air machinery, it appears, will work a major part of the miracle.

This one-time land of stately magnificence is to-day a dreadful waste, depressing to those who contemplate it in the light of its storied past. It is almost totally barren, containing squalid villages and decaying ruins of its quondam splendor, and the camps of roving tribes.

It needs, however, only the touch of the engineer's wand; and the engineers are on their way, electrical, mining, mechanical and civil engineers. Each is also by necessity and conviction a compressed air engineer. Compressed air will be employed in all their works and its marvels will do a giant's share of the toil necessary to recover Mesopotamia to the world as a useful economic unit.

Some of the projects have been examined by our representatives at Paris, who are of opinion that when the capital and machinery and energies of civilization are set to work in scientific exploitation there will be a handsome yield within two decades.

This wealth to-day merely is potential. In the tomorrows it will be real. What are these large sources of potential wealth? There is first the vast deposits and reservoirs of petroleum, the existence of which was known as far back as in the Roman period. Oil is believed to abound in the entire region, including, besides Mesopotamia, Mosul and Kurdistan. There are great stores, it is thought, of minerals. There is, finally, agriculture. Thus, if the age-old irrigation system is to be reëstablished with the modern improvements which American experience in the Western United States has proved good, there will be a great addition to the agricultural products necessary to feed Europe and Asia. The source of water would be the Euphrates and the Tigris and their fluids would furnish wheat and corn and would, it is believed, make the level and stoneless plains of these two great rivers become formidable rivals of the Southern American States in the growing of cotton.

Compressed air, a supple and obedient, a mighty, yet a gentle *Jinn*, and always ready to transform its shape, its use, its purpose, its power, at command, is to metamorphose Mesopotamia. Mobile air is much in little. It's motto should be, *"Multum in parvo."*

One is sometimes inclined to speculate whether the old lamp with which ALADDIN wrought his magic merely by a rub did not contain compressed air. At any rate the new Mesopotamian Nights (and Days) bid fair to eclipse the fables of its neighbor, Arabia.

Compressed air will be the magician.

THE POSITION OF CRUDE RUBBER

THE RUBBER market will always be of much interest to compressed air consumers. Rubber hose of all sizes and kinds is used in conjunction with pneumatic devices and is essential to the equipment for the performance of the useful work compressed air makes possible.

The crude rubber industry has been a little harder hit by the general business depression than any other, in that it did not share in the post-armistice boom that carried the price of everything else sky-ward. Steel is cheap now, so is copper, wool, cotton, hides, in fact, almost everything needful, but each of these industries had its day of high, inflated prices in 1919 and 1920. Producers of steel, copper, wool, cotton and hides, and the manufactures of every commodity made from these raw products had their "day in court," and when the slump came last Summer, it was their own fault if they hadn't feathered their nests and set their houses in order to withstand the shock that everybody knew was bound to come sooner or later—and some did and some didn't.

But with the producers of crude rubber nothing like this happened. On the contrary, the price of that commodity gradually declined from the government fixed war maximum of 1918, and almost without a single upward turn to gladden the hearts of those who had hoped for something different, now heads the list in the downward plunge.

A case in point is the automobile tire which consumes about 70 per cent of all the crude rubber marketed in a given year. There are

a great variety of things that go into the make-up of a tire, but the two principal elements are rubber and cotton fabric. Most of the fabric used is the 17 1-4 ounce Egyptian combed variety, made from the imported Egyptian cotton or from the American-Egyptian cotton grown in Arizona and California. This is what happened to the prices of these commodities:—

	Rubber	Cotton	Fabric
1917	80	50	120
1920	40	180	250
1921	11	20	90

(Rubber and Cotton, cents per pound)
(Fabric, cents per square yard)

It is easy enough to see where the producers of Egyptian cotton and the manufacturers of fabric had every opportunity to make good. The price of cotton rose 260 per cent and stayed there for a long time. Fabric prices rose 108 per cent, but while this was going on, and while every other commodity price was performing similar acrobatic feats, crude rubber fell off 50 per cent.

To be sure, the price of Egyptian cotton and the fabrics has declined enormously, just as the price of almost everything has fallen, and the price of rubber is no exception, and it is now generally conceded that rubber prices are below the cost of production.

Of course, there is a reason for this, and the reason is over-production that began to develop before the general price advance set in. There are two causes that led to the accumulation of this surplus stock that has so badly disturbed the market. Rubber growers of the East watched the advance in automobile production in this country and saw that we were increasing from year to year at a most rapid rate—from 569,000 cars in 1914, to 892,000 in 1915, to 1,584,000 in 1916, and to 1,869,000 in 1917. They thought this sort of thing would go on indefinitely and kept producing to meet the growing demand. But in 1918, on the contrary, there were only 1,154,000 automobiles manufactured in this country, and a rubber surplus began to accumulate.

Accentuating this trouble, the United States government sharply restricted importation of rubber in 1918 in order to conserve steamship space for other and more necessary war-work, and, from May to December of that year, but a small portion of a normal import was permitted to enter this country. Taking little heed of what should have been an evident conclusion, rubber producers went merrily on producing from year to year at the old rate of yearly increase—knowledge of the surplus and price reduction notwithstanding. The net result has been that the world finds itself today, with a stock of crude rubber on hand estimated approximately at 300,000 tons, of which, about 110,000 tons are in the United States, the balance being distributed throughout the world with London and Singapore the chief holders.

Good business practice requires that a certain stock of raw materials shall always be on hand to meet manufacturing demands. In crude rubber this amount is variously estimated at between 100,000 tons and 150,000 tons according to the times and business conditions. It is quite safe to say, therefore that the rubber market of the world is over-stocked by from 150,000 tons to 200,000 tons, and this fact is sufficient to account for the continued price decline already mentioned.

It was not until last summer when deflation set in in real earnest, that the rubber growers woke up to the fact that something had to be done to save themselves. Prior to that time they had based their hopes upon America, because our country consumes two-thirds of all the rubber grown, and they could not or would not believe that a depression of serious proportions could come to a country as prosperous as ours. But when the fact became apparent that the United States was by no means immune from such disturbances and that our deflation was likely to be drastic and long-lived, rubber planters adopted the only feasible plan open for their protection, and they began a systematic curtailment of production. This movement has now been in progress for ten months or more with varying results. Starting with an appeal for a voluntary reduction of 25 per cent in Malaya, Sumatra, Java and Ceylon, it was soon discovered the scheme was not likely to work out satisfactorily and the Planters' Association of Malaya, being by far the largest producer, conceived the idea of a 50 per cent reduction in which the weak plantation owners should receive financial help from the government in order to tide them over. The British Secretary for the Colonies at London, after consulting with the Rubber Growers' Association also at London, turned the proposal down.

The London Association is composed of large plantation owners of Malaya and are a powerful body. They did not approve of a plan that would permit the government to "hold the umbrella over the small producer." They had no great desire to aid him for, they figured, with a large number of producers "frozen out," the position of the other estates, generally, would be much improved. The failure of the 50 per cent reduction with government support threw the matter back to the 25 per cent voluntary scheme which is now working out with most extraordinary results. Private reports show that many estates are carrying out the 25 per-cent plan religiously—others are curtailing their 1921 production as much as 50 per cent—some have paid little attention to the plan, while others have ceased tapping the trees altogether. The net result up to the present time according to private advices, shows that Malaya, as a whole, is probably restricting production from 20 to 25 per cent below 1920 amounts.

Taking the present surplus and the reduction in the manufacture of tires and other rubber goods into consideration, this curtailment is not sufficient to accomplish any immediately helpful results. That the situation is improving the condition of the large estate owners that are strong enough to withstand the shock is seen on all sides. In Malaya and other producing centres there are a great many small estates owned by natives and Chinese. These range from 5 to 50 acres each and are in the hands of people of no means whatever, many of whom have already abandoned the field, allowing their areas to grow up to jungle (as all tropical areas will shortly after being abandoned). The law of supply and demand is doing what voluntary restriction cannot do. Rubber cannot long be produced at a cost above the selling price and the situation is now one of the survival of the fittest.

FRANCIS BACON CROCKER

"ONE OF THE outstanding pioneers of the electrical industry" was the manner in which Thomas A. Edison characterized the late Professor Francis Bacon Crocker whose death occurred in mid-summer. Further "His teaching as founder and head of the school of electrical engineering of Columbia University contributed much to the growth and importance of the electrical development of this country. As the first Chairman of the Standardization Committee of the American Institute of Electrical Engineers his painstaking work earned the lasting gratitude of everyone connected with the industry throughout the world."

Professor Crocker in his efforts toward electrical standardization also served as one of the two American delegates to the International Electrotechnical Commission in London and at its sessions did much to make worldwide electrical manufacturing successful.

His most important contribution to the electrical industry was the creation with Charles G. Curtis and Dr. Schuyler S. Wheeler, of the commercial motor put into use in 1886 and which was the forerunner of all the motors now in use. From that time until his death Professor Crocker was active in motor improvements, being credited with scores of patents relating to their construction and application. He was one of the founders of the C. & C. Co. (Curtis & Crocker, 1887) and of the Crocker-Wheeler Company, of which he was a director at his death.

In 1917, with Peter Cooper Hewitt, he developed the first helicopter in this country which would fly, the invention being taken over by the Government. Many of his discoveries in connection with the curvature of airplane wings are now in general use. Professor Crocker's scientific knowledge was extraordinary and was not entirely confined to electricity and aeronautics. He was probably one of the best known consultants of inventors.

He was a former President of the American Institute of Electrical Engineers, the Electric Power Club, the New York Electrical Society and a past Secretary of the International Electrical Congress. For twenty years he served as head of the School of Electrical Engineering at Columbia.

In reporting upon the Norwegian whaling industry, Consul Carlson, of Christiania, states that not more than eight whaling boats will be engaged in the whaling industry this year, as compared with 33 during 1920. It is reported that in the harbor of Sandefjord, Norway, there are at present a number of floating cook ships with not less than 124,000 vats of unsold whale oil on board.

WORLD-RECORDS OF DETROIT

WE BRING together under the above heading three items of current news which should be of interest to our readers.

THE BIG BRIDGE

The following details of the bridge to be built across the Detroit River are given out by MR. CHAS. EVAN FOWLER, Chairman of the Board of Engineers:

The total weight of the steel will be about 107,000 tons, or twice as much as in the great Quebec bridge; three times the combined weight of the Queensboro and the Manhattan bridges—the two largest New York Bridges; and six times as heavy as the steel in the Woolworth Building. The weight per foot of the bridge will be four times that of the old Brooklyn Bridge, and equal to that of the Williamsburg and Manhattan bridges combined. The bridge will carry a load twice as great as could be carried by the three great East River suspension bridges combined. There will be 50,000 miles of wire used, or enough to reach twice around the earth. If all the steel to be used were made into cable wire, it would reach to the moon and back. The cables, hung on end, would support twice the weight of the entire bridge. If all the steel were made into a one inch round rod, it would be 15,000 miles long.

NEW FORD RECORD

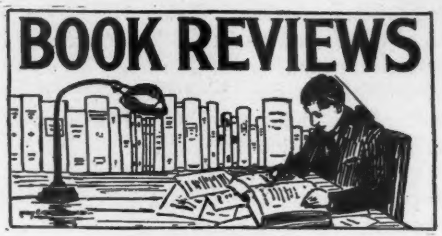
A new high record for production in one month was reached at the Ford Motor plant at Detroit, Mich., in June, the total cars and trucks being 108,962, a statement by the company says: The July schedule called for an output of 109,000 cars and trucks. A car or truck will leave the assembly line every six and one-half seconds, if this schedule is maintained—a production of 4,360 cars a day.

THE BIGGEST COOLING TOWER

It is claimed that the cooling tower erected by the Dodge Brothers at their Detroit plant is the largest in the world. It is 146 feet long, 42 feet wide and 104 feet high. It is capable of cooling 18,000 gallons of water per minute from a temperature of 105 degrees to 85 degrees when the outside temperature is 72 degrees and the relative humidity is 69 per cent. With other atmospheric conditions the water will be cooled to within 25 degrees of the existing dew point with a minimum temperature of 45 degrees. The loss of water by evaporation under these conditions amounts to five per cent.

The *Buenos Aires*, running between San Francisco and Scandinavia, loads up with 1,500 tons of fuel oil at San Francisco, sells 800 tons at Stockholm, and returns to America with some oil left in her tanks, having used 600 tons out of the 1,500 tons of her supply in her engines. She pays £7,500 for her oil in San Francisco and sells 800 tons of it at Stockholm for £8,000. The fuel is carried mostly in the double bottom, and therefore does not detract from the ship's cargo-carrying capacity.

The iron production in France for 1920 was 13,871,187 tons, and in 1919 it was 9,429,789



HELIUM BEARING NATURAL GAS, by G. SHERBURNE ROGERS. Professional Paper 121, Department of the Interior, U. S. Geological Survey, Washington, D. C. Copies may be procured from Supt. of Documents, Government Printing Office, Washington, D. C. Price, 30c.

THE EXCITING interest which the gas helium created among scientific men after its discovery on the earth by Sir William Ramsay in 1895 received an energetic stimulus during the first year of the World War when a British scientist conceived the idea of using helium instead of hydrogen for inflating balloons and which inspiration afterward resulted in the discovery of quantities of the element in natural gas deposits in the United States.

The purpose of the Survey's investigation was made strictly for military purposes and it was therefore directed toward locating an adequate supply of helium bearing gas as speedily as possible. In this paper, it has been deemed desirable to present at this time a brief description of the chief sources of helium in the United States and at the same time to describe the broader geologic relations of the helium bearing gas, to discuss various theories of its origin and to review the reported occurrences of helium in minerals and in other gases.

It is an instructive and most interesting description and will be a valuable means of reference to those engaged in this comparatively new and important industry, which apparently has great possibilities of development.

PUNCHES, DIES AND TOOLS FOR MANUFACTURING PRESSES, by JOSEPH V. WOODWORTH, author of "Dies, Their Construction and Use," American Tool Making and Interchangeable Manufacturing, etc. Nearly 700 engravings, 483 pp., cloth, $4.50. New York: The Norman W. Henley Co.

THIS BOOK has been written and compiled by a practical man for the use of all practical men who are interested in the working of sheet metals, the designing and constructing of punches and dies and the manufacturing of repetition parts and articles in presses.

The author says that throughout the entire volume he has endeavored to eliminate all obsolete processes, designs and methods and to confine himself exclusively to the design, use and adaptation of the numerous sets of tools illustrated.

The present volume is broader and more comprehensive than the first, and deals with many more branches of the art and treats in a less detailed manner of the methods of construction.

The author is to be congratulated on this comprehensive compilation and until its publication there had been but little literature on a subject of much importance in the mechanical arts.

MANHOOD OF HUMANITY, THE SCIENCE AND ART OF HUMAN ENGINEERING, by ALFRED KORZYBSKI. Price, $3.00; 264 pp. New York: E. P. Dutton & Co.

IT HAS long been recognized by all those who have pondered on the present economic, social and commercial aspects of human society that a vitally important need of the present time is a prevailing correct idea, a true concept of what Man really is.

A farmer must know the natural laws that govern his wheat, corn, or cow, Count Korzybski tells us, or otherwise he will not have satisfactory crops or the quality and abundance of milk he desires, whereas the knowledge of these laws enables him to produce the most favorable conditions for his plants and animals and thereby gain the desired results.

In like manner, humanity must know the natural laws for humans, otherwise humans will not create the conditions and the customs that regulate human activities to the best advantage.

It has been found that maximum production may be attained only when the production is carried on in conformity with certain psychological laws. Hence this leads the author to his definition of engineering, which when rightly understood, "is the coördinated sum-total of human knowledge gathered throughout the ages, with mathematics as its chief instrument and guide." Here is quoted the definition of mathematics by Professor Cassius J. Keyser in his book *The Human Worth of Rigorous Thinking* (Columbia University Press, 1916), Mathematics is the science of "Exact thought or rigorous thinking" and one of its distinctive characteristics is "precision, sharpness, completeness of definition." The following quotation from Brandeis is included:

> "For a while he trampled with impunity on laws human and divine but, as he was obsessed with the delusion that two and two make five, he fell, at last a victim to the relentless rules of Arithmetic.
>
> "Remember, O stranger, Arithmetic is the first of the sciences and the mother of safety."
>
> BRANDEIS.

This book for the first time brings Man's evolution and welfare into the field of the exact sciences particularly that of engineering and treats in terms of mathematical conciseness the development of human progress.

RED LEAD, AND HOW TO USE IT IN PAINT, by ALVAH HORTON SABIN, M. S., D. Sc. Member of the American Chemical Society, Third edition, rewritten and enlarged. Illustrated, 139 pp., cloth, $2 net. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd. Montreal: Renouf Publishing Co.

THE GREAT increase of interest which is being displayed in red-lead as a protective coating for bridges and other metal structures, makes the appearance of this new edition of Dr. Sabin's authoritative treatise especially important. The essential facts about red-lead paint are presented in a clear and easily readable manner, backed up by the author's thirty years' experience and study of paints of all kinds. Compared with the second edition, which was issued early in 1919, this new printing has been rewritten and amplified to an extent so considerable as to make it almost a new book.

The greatly advanced cost of all metal structures makes the question of their future pres-

ervation of ever-increasing importance, and leads to more discussion of the proper methods in the meetings of engineers.

Dr. Sabin tells in the preface about a recent communication of the Illinois State Highway Commission describing a bridge more than 200 feet long over the Fox river at Ottawa, in which rust had formed between the web plate of the rib carrying the sidewalk and the flanges of the adjacent sections, developing enough expansive force to rupture the connecting rivets, which were of tough and ductile material. In one place there was ten feet with only one unbroken rivet, and in general only ten per cent of the rivets connecting the upper and lower halves of the arch ribs were unbroken. The engineer says: "A circus outfit had been allowed to cross the bridge a short time before the examination was made. It was reported that the vibration was so great that oil lanterns hanging from the overhead sway bracing swung up against the supports with sufficient violence to break the globes. It is also said that the leading elephant gingerly placed one foot on the bridge, then with a snort of disgust lumbered down stream a couple of blocks and swam across.

The recent introduction of red-lead in paste form, made possible by improvement in the pigment, has greatly increased its availability for more extensive use on bridges, buildings, ships, etc. In fact, the author predicts that the next step will be its sale as liquid paint, ready for use, when the demand for it will perhaps equal that for white lead.

Tables are appended for the convenience of those who use the British measures.

Report No. 98, the Design of Wind Tunnels and Wind Tunnel Propellers, II, by H. F. Norton and Edward P. Warner, has been recently issued by the National Advisory Committee for Aeronautics at the Washington Printing office.

The report was undertaken at the Langley Memorial Aeronautical Laboratory for the purpose of supplying further data to the designer of wind tunnels. Both a one foot and a five foot tunnel were used which made comparisons possible. Particular stress is placed on the study of directional variation in the wind stream.

Undoubtedly there is considerable yet to be done in obtaining experimental formulae for the design of wind tunnels for various purposes and this report will aid in clarifying a number of phases of the work heretofore unknown.

CLEANER FOR ELECTRICAL MACHINERY

If compressed air is available, there is no better way to clean electrical equipment such as generators and motors, according to *Scientific American*, than with a newly developed cleaner. This is a device which is clamped directly to the air hose, and is provided with a quick-acting hand valve that gives complete control. The shape of the cleaner is such that it can reach in otherwise inaccessible places.

New Mining Publications

THE BUREAU OF MINES of the Department of the Interior has published the following new bulletins and technical papers:

BULLETIN 189. Bibliography of petroleum and allied substances in 1918, by E. H. Burroughs. 1921. 180 pp.

BULLETIN 198. Regulation of explosives in the United States, with especial references to the administration of the Explosives Act of October 6, 1917, by the Bureau of Mines, by Charles E. Munroe. 1921. 45 pp.

TECHNICAL PAPER 246. Water-gas apparatus and the use of Central District coal as generator fuel, by Wm. W. Odell. 1921. 28 pp., 1 pl., 2 figs.

TECHNICAL PAPER 270. The detection and estimation of platinum in ores, by C. W. Davis. 1921. 28 pp.

TECHNICAL PAPER 280. Accidents in metallurgical works in the United States during the calendar year 1919, by W. W. Adams. 1921. 29 pp.

Report of Committee on Standardization of Petroleum Specifications, Bulletin No. 5. 1921. 71 pp. Gives specifications for petroleum products used by the United States Government and describes methods of testing.

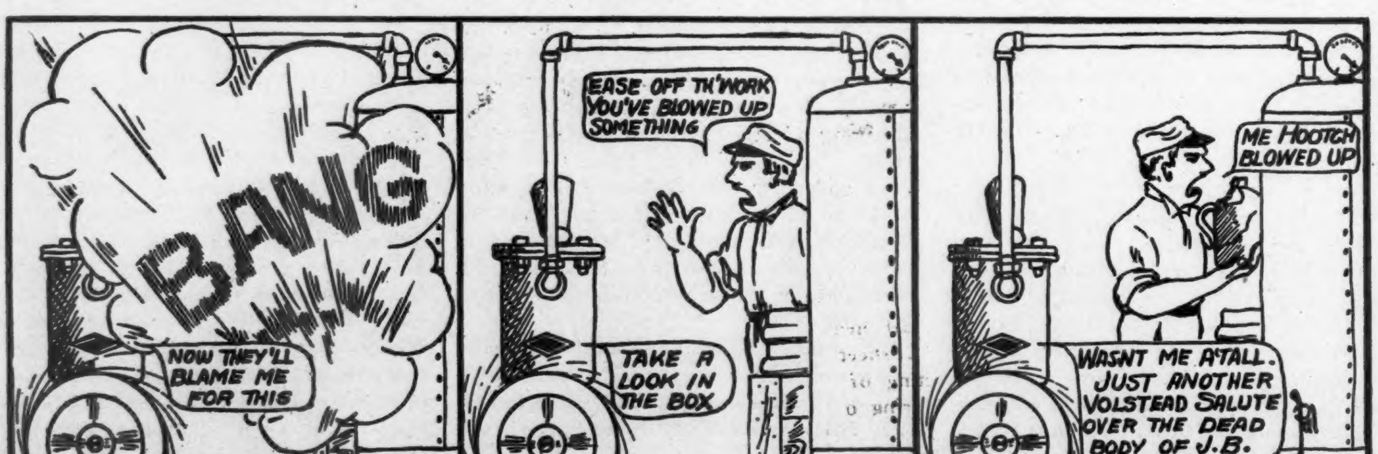
NOTE.—Only a limited supply of these publications is available for free distribution, and applicants are asked to cooperate in insuring an equitable distribution by selecting publications that are of especial interest. Requests for all papers can not be granted. Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

PASSING ALONG A RECORD

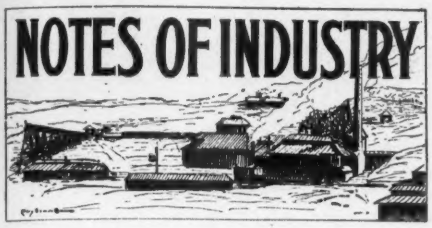
Some time ago we (*the South African Mining and Engineering Journal*) announced a remarkable record made by a miner by the name of Ellitson, at the Geduld mine, with No. 18 Ingersoll Leyner drills. We have just been advised by the Union Corporation that this same miner broke his previous world's record with the same three machines in the same grade of rock and the same stoping width. The record which he has made during the month of April is as follows:—Type of drill, No. 18 Ingersoll Leyner drills; number of drills, 3; total machine shifts, 78; total fathoms broken, 221; fathoms per machine shift, 2.83; tons broken per machine shift, 45; stoping width, 63 inches. As Mr. Ellitson has used these same drills for a considerable length of time, and made remarkable fathomage in four consecutive months last year—that is, August, September, October, and November—he deserves a great deal of credit for making special efforts to break his own record with these same machines. Ordinarily, a man asks for new machines whenever he wishes to make a special record. This figure of 2.83 fm. per machine shift is a remarkable performance, and we believe stands unequalled in the world to-day under the same conditions, and not using more than three drills.

A woodpecker pecks out a great many specks
Of sawdust when building a hut;
He works like a nigger to make the hole bigger,
He's sore if his cutter won't cut.

He don't bother with plans of cheap artisans,
But there's one thing can rightly be said:
The whole excavation has this explanation;
He builds it by using his head.



NOT GUILTY



The Department of Agriculture has just received samples of the first run of wood pulp from the new mill which has been lately established near Juneau, Alaska. The mill is operated by hydro-electric power resources to increase the output to 250 tons. It is later planned to enlarge the mill to manufacture paper. It is stated by forest officials that an area equaling 2,000,000,000 feet of pulp-making timber in the Tongrass National Forest will soon be placed on the market in response to inquiries from prospective manufacturers.

Two new educational motion picture films are ready for distribution by the United States Bureau of Mines. "A Dollar Saved is a Dollar Earned," produced in coöperation with the National Association of Pipe Covering Industries, shows the advantages and economy that result when pipes and boilers are properly insulated and the radiation losses are thus overcome. "The Story of Ingot Iron," a three-reel picture showing the various steps in the process of making ingot iron for plates and sheets, was produced in coöperation with the American Rolling Mills Co., of Middletown, Ohio. Requests for the loan of these films should be addressed to the Bureau of Mines, 4800 Forbes St., Pittsburg.

Compilation of production statistics just issued by the Geological Survey shows that from 1857 to and including 1918 there were produced throughout the world 7,503,147,138 barrels of crude petroleum, of which the United States supplied 4,608,571,719 barrels. Russia furnished almost 25 per cent. In the latest yearly statistics, those of 1918, the United States produced 355,927,716 barrels, while Mexico furnished more than twelve per cent and Russia almost eight per cent.

During the year 1920 freight valued at $1,000,000 was transported by airplane from the United Kingdom in cargo planes to France, Belgium, Denmark, Spain, and Holland. Planes coming into England from the Continent carried $2,000,000 worth of imports.

The first approval of an industrial gas mask for use in ammonia fumes has been issued by the United States Bureau of Mines to the Mine Safety Appliances Company of Pittsburgh, Pa. The Burrell ammonia mask successfully passed the exhaustive series of tests given by the bureau's chemists in accordance with Schedule 14, "Procedure for establishing a list of permissible gas masks."

The gas mask used during the war by the United States Army was largely developed under the direction of the Bureau of Mines and the Chemical Warfare Service. Since the war the Bureau of Mines has been engaged in adapting and developing the gas mask for industrial purposes and promoting its safe usage.

The Burrell ammonia mask consists of an Akron type, Tissot face piece that allows breathing through the nose, fitted with a special ammonia canister containing copper sulfate pumice stone mixture devised by G. St. J. Perrott, Max Yablick and A. C. Fieldner for the Ordnance Department of the United States Army. It has been found to give absolute protection in any percentage of ammonia gas which the wearer of a mask can stand without unbearable skin irritation.

A noticeable reduction during the last ten years in the number of draft animals employed in the largest cities was shown by the 1920 census. The Census Bureau showed 56,539 horses in New York City as compared with 128,224 in 1910 and 30,088 in Chicago, against 68,122.

Figures for other cities announced recently included: Philadelphia, 19,472 and 50,461; Baltimore, 7,378 and 15,346; Boston, 10,093 and 23,007; Pittsburgh, 6,032 and 12,845; Cincinnati, 5,031 and 13,901; Cleveland, 4,924 and 16,839.

At a meeting of the Board of Directors of the Greenfield Tap and Die Corporation, held recently, it was voted to purchase the entire capital stock of the Greenfield Machine Company, Greenfield, Massachusetts, manufacturers of Cylindrical and Universal Grinders, and the Morgan Grinder Company of Worcester, Massachusetts, manufacturers of Internal Grinders. The combination of the Morgan Grinder Company and the Greenfield Machine Company will constitute the Machine Division of the Greenfield Tap and Die Corporation.

The number of wooden wedges used in the mines of the Rand during a month ranges from 300,000 to 400,000. Hammer handles are used at the rate of some 40,000 to 50,000 a month, and from 200,000 to 300,000 plugs are also consumed.

A hollow metal ball calculated to be particularly valuable for ball valves is now made by the Seamless Hollow Ball Co., Highlandtown, Baltimore. The ball is made from one piece of metal, by a patented process, in various sizes and with thick or thin walls. Steel, brass, bronze, copper, Monel metal and aluminum are among the metals from which the balls are made.

A liquid fire projector, of a similar type to that used in the Zeebrugge raid during the war, portable and simple in operation, has been placed on the market for use in agricultural purposes. It weighs 50-60 lbs., and may be carried over the shoulders like a golf bag. It is capable of projecting liquid fire 80-90 ft. for about half a minute, or it may be made to give intermittent shots. This apparatus is said to have been used successfully in tropical climates for combating locusts, and for destroying flying foxes in Queensland.

Mr. W. S. Findlay, Jr., vice-president of the American Water Works & Electric Co., has been elected chairman of the Metropolitan section of the American Society of Mechanical Engineers comprising more than 3000 members in the Metropolitan district.

* * *

Mr. A. W. L. Gilpin was tendered a banquet at the Milwaukee Athletic Club by 208 Ford Motor Co. dealers of Wisconsin on the occasion of his promotion to district manager of the Ford Motor Co. Mr. Gilpin has transferred his headquarters to Chicago as manager of the Middle Western branches and assembling plant.

* * *

Mr. R. C. Limerich has been recently appointed state highway engineer of Arkansas, succeeding Mr. Lloyd Hooper, who resigned.

* * *

Mr. Donald P. Hess has recently succeeded C. N. Replogle as general manager of the Columbus plant of the Timken Roller Bearing Co., the latter having resigned. Mr. Hess served as chief of the priority section of the motor transport section in the war.

* * *

Mr. B. A. Briggs has resigned as superintenden of streets, Colorado Springs, Col., and is now stationed with the Colorado State Highway Department.

* * *

Mr. Herschel C. Smith has been appointed assistant professor of highway engineering and highway transport at the University of Michgan. Mr. Smith had formerly been Deputy State Highway Engineer of Oklahoma.

* * *

Mr. Edgar E. Clark has been reelected commissioner of the Interstate Commerce Commission for the year ending June, 1922.

* * *

Mr. Harry O. Garman was recently elected president of the American Association of Engineers at the annual meeting. Mr. Garman is chief engineer of the Indiana Public Service Commission.

* * *

Mr. F. A. McLean, publicity manager of the Canadian Ingersoll-Rand Co., has been visiting New York and vicinity investigating trade journal advertising methods in the interests of his company.

As soon as general business conditions become more settled and nearer normal, the Bethlehem Steel Corporation will expand its facilities at Sparrows Point, plans for which are ready. The additions, it is estimated, will cost about $25,000,000, and will provide employment for about 8,000 men. The present ore facilities will be greatly increased, including an expenditure of $1,000,000 for deepening the ship channel from the main outlet to the piers.

GREATEST POWER PER SHAFT IN NEW U. S. WARSHIPS

THE ELECTRICAL operation of the United States Navy's new line of six battle cruisers, now building under the 1916 naval programme, will represent, according to Rear Admiral R. S. Griffin, Chief of the Bureau of Engineering, "the greatest horsepower per shaft that has ever been projected in any marine installation irrespective of the type of motive power."

Speaking of these war vessels, and of the six new battleships that are also part of the programme, and emphasizing what this means in making the United States preëminent among all nations in marine engineering, Admiral Griffin says:

"In the case of battleships Nos. 49 to 54, the installations represent an increase to 60,000 horsepower; that is, double the most powerful electric drive installations previously designed; and in the battle cruisers 180,000 horsepower is to be carried by four electrically driven shafts."

"This is by far the greatest horsepower per shaft, so far as this bureau is aware, that has been projected in any marine installation irrespective of the type of motive power."

Announcement of the interesting details of the electrical features of these new ships, carefully guarded until the specifications were drawn up and approved, came coincident with the annual report of former Secretary of the Navy Daniels, and the completion of tests by the Bureau of Engineering showing that the battleship *New Mexico,* which attained the highest merit in engineering for the year of any battleship, shows a saving of fifteen percent of fuel used per mile, as compared with a similar turbine driven battleship which was second in comparison. This is at least an indication of what the government thinks of the advantages of the electric drive.

The new line of battle cruisers to be named, *Lexington, Constellation, Saratoga, Ranger, Constitution* and *United States,* will be the longest fighting craft in the world. Their dimensions are: 874 feet long; beam, 105 ft. 5¼ inches; draft, 31 ft.; weight, 43,500 tons; speed, 33.6 knots an hour.

In order to move this tremendous mass of steel and armor plate through the water at express rate speed of nearly 40 miles per hour, eight huge electric motors, each fifteen feet in diameter, weighing 223,000 pounds, and with a horsepower capacity of 22,500, are connected in pairs to each of the four propeller shafts. This is twice the number of motors used even on the largest present electrically propelled super-dreadnoughts. The full force of these motors is capable of turning over the propeller blades at 320 revolutions per minute, exerting a total of 180 h. p.

One hundred and eighty thousand horsepower of electric energy is enough to supply light and power to a city of 700,000 population. One of these cruisers for instance, if anchored in Boston harbor would generate enough current to take care of the demands of the whole city. And the astonishing part of it is that these vessels not only generate this power but actually absorb it all for their own use. The amount of current used to drive the cruisers would operate 50 large merchant ships.

The design of the electric installation for the battle-cruisers *Lexington, Saratoga, Constitution* and *United States* is already progressing rapidly under the direction of W. L. R. Emmet, consulting engineer of the General Electric Company, and pioneer in the development of the electric drive. Mr. Emmet was the designer of the first electrical installation for the Navy—that now in operation on the U. S. S. *New Mexico.*

The new battleships are to be named *South Dakota, Indiana, Montana, North Carolina, Iowa* and *Massachusetts.* They will be 684 ft. long, 106 ft. wide, having a draft of 33 feet and weighing 43,000 tons. Their full speed will be 23 knots, two knots higher than any American superdreadnought now in operation.

Like the battle-cruisers, they will be driven by four propellers equipped however, with but four instead of eight motors of 15,000 h. p. each and with a shaft horsepower of 60,000.

The total weight of the propulsion apparatus of the cruisers will be about 1,400 tons and about 800 tons for the battleships. The cruisers will carry 18,500 feet of electric main cable weighing 221,580 pounds and the battleships 5,600 feet weighing 68,000 pounds.

Both types of ships, in addition to the main propulsion apparatus described will carry auxiliary turbine generators for the creation of electricity for all other uses except propulsion. One of the most interesting features of the electric drive is the operation of the electrical apparatus at different speeds or the arrangement of motors and generators.

The specifications of the Navy Department state that one generator operating four motors must drive the battlecruisers at nineteen knots, two generators operating four motors at 19.25 knots and four generators and eight motors at from 25 to full speed or 33.6 knots.

The battle-cruisers will each be equipped with no less than four turbine generator units driven by steam from sixteen oil fired boilers. This apparatus creates the electric energy. The turbine generators have a rating of 5000 volts each and revolve at the tremendous speed of 1,770 revolutions per minute. The rating of the turbine generators for the battleships is 26,600 volts. These ships will be equipped with but two generators.

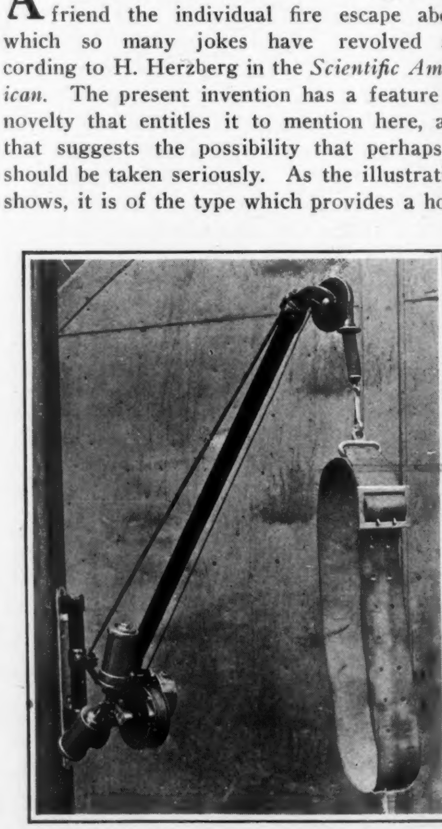
A LONG PIPE LINE ALL WELDED

The following should be of special interest to all who have to do with the long distance transmission of compressed air. While the welding of the joints must be more economical and satisfactory than any other means, the one especial feature in its employment for air transmission is the complete elimination of the great losses by leakage which are such a common experience.

The new 28-mile pipe line of Butte, Montana, recently completed at a cost of something more than $1,000,000 carries water from the Atlantic watershed to a city on the Pacific slope. The use of welding instead of other types of joints, is one of the most important features of the project from an engineering point of view. The new line is composed partly of one-half inch thick, double-coated steel pipe, the sections being on the average 17½ feet in length and weighing from 2,000 to 2,400 pounds, according to diameter. There are about five miles of the steel pipe in which the working pressures vary from 350 to 400 pounds per square inch. In one place a grade of 38 degrees is maintained for a distance sufficient to elevate the line 400 feet, and there is a lift of 800 feet in a distance of 3,000 feet—from pumping plant to standpipe. The construction of the pipeline required 1,125 tons of steel pipe. The reason for using welded construction was primarily one of efficiency, though it also resulted in a marked economy. To have secured the same strength in the joints with screwed pipe much heavier pipe would have been required.

A COMPRESSED AIR FIRE ESCAPE

AMONG recent inventions is our good old friend the individual fire escape about which so many jokes have revolved according to H. Herzberg in the *Scientific American.* The present invention has a feature of novelty that entitles it to mention here, and that suggests the possibility that perhaps it should be taken seriously. As the illustration shows, it is of the type which provides a hoist



The air cylinders force this hoist to ease its user to the ground gently in the event of fire.

to lower its user to safety from the window, to the frame of which it must be attached in advance. The interesting item is the use of compressed air cylinders to ease the drop and make it at once safe and rapid. After duly attaching the belt, the user turns on the air, and sufficient resistance is afforded by the piston to the turning of the sheaves on which the cable runs to insure that he be deposited with sufficient gentleness to avoid broken bones. The entire apparatus weighs no more than 25 pounds, and is accordingly easily transportable.

WIND TURBINES

THE ADVENT of the wind turbine has in Europe greatly increased the importance and value of wind power installations and extended their scope of employment. The "Hercules" turbine here illustrated is built by the *"Vereinigte Wind Turbinen Werke, G. m. b. H., Dresden-Reick."* The wheel is made entirely of steel and iron, the vanes of zinc coated, pressed sheet steel, and, as the circumferential speed of the wheel increases radially, they are curved or twisted and rigidly mounted on the wheel.

Regulation according to the force of the wind is obtained by a small auxiliary rudder. Increasing wind pressure impinging upon this auxiliary rudder presses it backward and thereby places the whole face of the wheel at an acute angle to the direction of the wind, Fig. 2, thereby reducing the effective area of the blades. When the wind decreases, the wheel is again turned into the wind by the pull of strong vertical springs.

The turbine may be put out of work by means of a hand operated winch at the foot of the tower. Hereby the side rudder with the wheel arranged parallel to it comes to rest against the main rudder, and the wind can then impinge on the blades only at a very sharp angle. The amount of safety thus attained is very great. Such turbines, for example, have successfully withstood hurricanes of 75 feet per second without damage.

Owing to the improvement of the entire arrangement, as compared with the old types of wind motors, it has been made possible to utilize breezes of only ten feet per second, whereas the older constructions do not answer to anything less than eighteen to 22 feet per second. Consequently the number of wind-hours utilized is very high. According to tests made by the *Kaiser-Wilhelm-Institut fur Landwirtschaft* 6,000 to 6,500 wind-hours a year have been recorded.

"Hercules" wind turbines are very extensively used in Holland for drainage purposes. Fig. 1 shows the largest which has ever been built. The rotor has a diameter of 50 feet, the diameter of the "worm" which lifts the water being six feet. The water is lifted to a height of two feet nine inches to four feet six inches. This turbine has been working since 1913 to drain the so-called *Koog*, a marshy dyked-in-piece of agricultural land. Previously it has been drained by twelve wind-

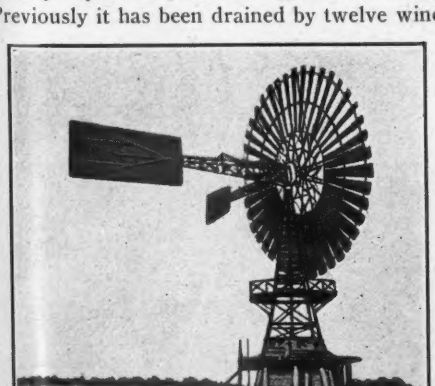


Fig. 1. Largest wind turbine in the world.

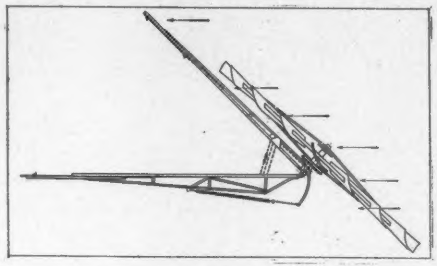


Fig. 2. Hercules wind turbine in a strong wind.

mills and one wind motor. At a wind velocity of sixteen feet per second the turbine is capable of lifting 1,000 to 1,050 cubic feet per minute, the worm making 31 revolutions.

THE FIRST SUCCESS OF THE LEYNER DRILL

THE FOLLOWING interesting matter, which is completely self-explanatory, is from a letter by George E. Collins, Denver, Colo., to the editor of *Mining and Scientific Press*, San Francisco, June 25, 1921:

"In your editorial on Mr. Brunton it is stated that the Leyner drill first came into prominence in the driving of the Roosevelt adit. This is hardly correct: it had been most successfully used, and had become widely known, in the driving of the Newhouse and other adits around Idaho Springs several years before. In fact, the Leyner drill was virtually a product of the Newhouse tunnel; new patterns were successively tried out there, often following suggestions made by the Tunnel staff, and especially by S. A. Knowles, who was for many years in charge of work in the heading.

"I think the Leyner drill was one principal cause of the very low costs of driving the Newhouse tunnel in 1906 and 1907: costs which I think have never been equaled under comparable conditions. Another cause was the system of drilling the round with a bar, set up across the muck-pile, a system which, so far as I know, was first used at the Newhouse tunnel, and which was rendered possible by the Leyner drill."

REDUCED STEAM WASTAGE OF AIR BRAKE PUMPS

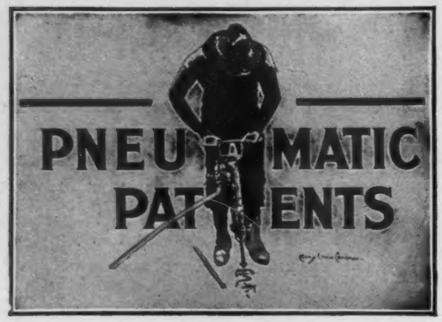
THE FOLLOWING occurred in the discussion by Mr. E. H. Dewson of a paper by Mr. Geo. M. Basford before the New York Railroad Club, May 20, 1921.

Up to the time Mr. Basford mentioned the air compressor also was "as simple as a grindstone," but appreciating that the simplicity of the well known 9½-in. and 11-in. compressors was obtained at the expense of a high consumption of steam, and influenced by the enormously increased demand for compressed air, due to the longer trains hauled and the use of many air operated labor saving devices, the brake builders brought out the 8½-in. cross compound compressor of about double the capacity of the 11-inch pump. As its name implies the expansive power of the steam is utilized by expanding it from one cylinder into another of greater diameter, and the air is compressed to main reservoir pressure in two stages, thereby effecting marked economy.

Two 11-in. simple steam driven compressors, when delivering an amount of compressed air equal to the capacity of the 8½-in., 150-ft. cross compound compressor, at pressures ranging from 100 to 140 pounds per square inch, will consume three times as much steam as the 8½-in. cross compound under the same conditions. It has been estimated that 117 tons of coal would be required to supply the steam used by an 8½-in. cross compound in providing the average amount of air used by a 70-car freight train operating ten hours per day and 325 days per year, with brakes in average condition. A saving of 234 tons of coal per freight locomotive per year by the use of the cross compound compressor instead of two 11-in. pumps seems incredible, but even though the maximum amount possible is not realized, the saving is well worth going after at the present price of coal.

RECORD OF AEROPLANE ENGINE PERFORMANCE

REPORT NO. 108 of the National Advisory Committee for Aeronautics is based upon an analysis of a large number of aeroplane engine tests made at the Bureau of Standards, and it contains the results of research to determine the fundamental relations between many variables of engine operation. The data used have been taken from over 100 groups of tests made upon several engines, including the Liberty 12 and three models of the Hispano-Suiza. The tests were made in the altitude chamber, where conditions simulated altitudes up to about 30,000 ft., with engine speeds ranging from 1,200 r.p.m. to 2,200 r.p.m. The compression ratios of the different engines ranged from under 5 to 1 to over 8 to 1. The data taken on the tests were exceptionally complete, including variations of pressure and temperature, besides the brake and friction torques, rates of fuel and air consumption, the jacket and exhaust heat losses. With the Liberty engine operating at from 500 r.p.m. to 2,000 r.p.m., and with the 300-h.p. Hispano-Suiza operating from 1,400 r.p.m. to 2,200 r.p.m., it was found that the friction torque increases approximately as a linear function of engine speed at a given air density, and approximately as a linear function of density at a constant speed. From this it follows that the friction horsepower increases approximately as the square of the speed. Actually the relation of torque and speed is such that the friction horsepower increases with speed raised to a power between the first and second, this power increasing with speed, and approaching the square; the relation depends upon the engine design, the speed and the density of the air. Statements as to the distribution of the friction losses are based upon incomplete evidence, but the indications are that the pumping losses are about half of the total friction. There is no doubt that for a given process of combustion, and at a constant speed, the engine power is directly proportional to the weight of charge supplied; in other words, proportional to the charge density at the beginning of compression.



MAY 31.

1,379,654. STAGE - EFFECT - CONTROLLING DEVICE FOR USE IN CONJUNCTION WITH MOTION-PICTURE MACHINES. Frank R. Sommermeyer, Minneapolis, Minn.
1,379,694. ICE - MACHINE COMPRESSOR. Henry D. Pownall, Canton, Ohio.
1,379,708. BLOWPIPE. Clayton Laing, Chicago, Ill.
1,379,730. AIR-SEPARATOR. Thomas J. Sturtevant, Wellesley, Mass.
1,379,776. OZONIZER. Melvin J. Napier, Akron, Ohio.
1,379,800. MILKING-MACHINE. Romeo A. Casarotti, Nicasio, Calif.
1,380,016. ROTARY COMPRESSOR. Gustav B. Petsche, Yonkers, N. Y.
1,380,118. PNEUMATIC CENTERING-PUNCH. William Thompson Sparrow, Newport News, Va.
1,380,140. PAINTER'S BLOWTORCH. William Gretsinger, Baltimore, Md.
1,380,181. PUMP. Erasmus W. Beck, Griffin, Ga.
1,380,230. APPARATUS FOR THE TREATMENT OF MILK. John M. Manley, Montgomery, Ala.
1,380,322. PNEUMATIC DUST-SEPARATOR. Lycurgus Lindsay and Ernest M. Davids, Los Angeles, Calif.

JUNE 7.

1,380,695. PROCESS OF AND APPARATUS FOR PUMPING LIQUID AND GAS. Clarence C. Wilson, Corcoran, Calif.
1,380,759. PNEUMATIC BUMPER. James Knox Whitaker, Jr., St. Louis, Mo.
1,380,841. PNEUMOTHERMIC APPARATUS. Adolfo Salvador Salas, Buenos Aires, Argentina.
1,380,866. TOOL FOR APPLYING COATING. Herbert W. Day, Wollaston, Mass.
1,380,878. AIR-PUMP. George W. Wright, Lapel, and Raymond W. Nichols, Kokomo, Ind.
1,380,603. PNEUMATIC PUMP. Thomas E. Smythe, Hammond, Ind.
1,381,030. GAS-BURNER. Augustus F. Thompson, Huntington, W. Va.
1,381,095. FUEL-OIL BURNER. Fletcher C. Starr, Philadelphia, Pa.

JUNE 14.

1,381,111. PULSATOR FOR MILKING-MACHINES. Aaron D. Ellington, Springfield, Ill.
1,381,115. PUMP. Alois Gassenhuber, Jr., South Milwaukee, Wis.
1,381,133. ENGINE AIR-COMPRESSOR. Jakob Muller, Veltheim, Switzerland.
1,381,139. ELASTIC - FLUID - PRESSURE MULTIPLIER. Charles H. Smoot, South Orange, N. J.
1,381,144. BURNER FOR GAS AND OIL. Cornelius P. Valleiy, Bradford, Pa.
1,381,306. BLAST-NOZZLE. John M. Hopwood, Dormont, and Thomas A. Peebles, Pittsburgh, Pa.
1,381,401. BLOWER. Fred L. Cantwell, San Bernardino, Calif.
1,381,601. VACUUM GRAIN - CLEANER. Charles Argyle Torrence, Regina, Sackatchewan, Canada.
1,381,819. FAN OR BLOWER. Edward L. Garfield, Tuckahoe, N. Y.

JUNE 21.

1,381,912. COMBINATION JOLT RAMMING AND SQUEEZING MACHINE. Philetus W. Gates, Chicago, Ill.
1,382,018. AIR-PUMP. John H. Schreiber, St. Louis, Mo.
1,382,119. FLUID - PRESSURE CONTROL. Charles J. Pilliod, Toledo, Ohio.
1,382,143. AIR-OPENER FOR DOORS. Joseph Szczurek, Chicago Heights, Ill.
1,382,184. PUMP FOR EXHAUSTING AIR AND GASES. Henry Albert Fleuss, Thatcham, England.
1,382,334. FLUID-COMPRESSOR. Llewellyn Williams, Hollis, Long Island, N. Y.
1,382,444. SUCTION - CREATING APPARATUS. Benjamin Skidmore, Jr., Chicago, Ill.
1,382,453. AIR - COMPRESSING MACHINE. Michelle Barbetta, Paterson, N. J.
1,382,548. SUCTION CLEANING APPARATUS. Frank E. Robertson, Cleveland, Ohio.